U. S. DEPARTMENT OF ENERGY
FIELD WORK PROPOSAL

1. B&R No. KA150302	2. Contractor No.: 2011-BNL-PO121-Fund	3. Date Prepared: 20110301	4. Task Term: Begin: 20110401 End: 20150930

5. Work Proposal No.: N/A	6. Work Authorization No.: KACH131

7. Title:
LAB 11-438 Collider Detector Research and Development Program

8. Principal Investigator(s): Lanni, Francesco (631) 344-4865

9. Headquarters/Operations Office Program Manager: Borcherding, Frederick (301) 903-6989 10. Operations Office Work Proposal Reviewer: 11. Contractor Work Proposal Manager: Ludlam, Thomas (631) 344-7753 Gordon, Howard (631) 344-3740	12. Headquarters Organization: Office of Science 13. Operations Office: CHICAGO 14. Contractor Name: BROOKHAVEN SCIENCE ASSOCIATES BROOKHAVEN NATIONAL LABORATORY	15. HQ Organizational Code: SC 16. DOE Organizational Code: CH 17. Contractor Code: BN

18. Work Proposal Description (Approach, anticipated benefit in 200 words or less, suitable for public release) :

Hadron colliders will provide our major tool to explore the energy frontier for many years to come. However, to provide data sets with sensitivity to the highest mass scales will require a collider running at very high luminosities for a number of years. The particle flux that a detector must deal with at such luminosities provides major challenges in dealing with extreme data rates, in extracting maximum information for triggering, in event reconstruction despite large backgrounds, and in surviving very large amounts of radiation. Two of our major tools for event recognition are charged particle tracking detectors and calorimeters, both of which face major challenges. This proposal deals with R&D aimed at future detector components in these two areas. Our goals are both significant improvements in performance as well as cost reduction in the very large detectors expected at future hadron colliders.

The goals and the developments described in this proposal will also provide fundamental contributions to the design of future lepton collider experiments, to large volume imaging devices in long baseline neutrino programs, to space-based experiments and to other basic science fields where high precision measurements are extracted promptly from complex detector systems.

This proposal is a collaborative effort led by BNL in conjunction with LBNL, SLAC, ANL, and eleven universities.

19. Principal Investigator (s) :
Francesco Lanni
Signature(s) 03/01/2011 Date

20. Contractor Work Proposal Manager: T. Ludlam Signature 03/01/2011 Date	21. Operations Office Review Official: Signature Date

22. Detail Attachments:
- (☒) a. Purpose
- (☒) b. Approach
- (☒) c. Technical progress
- (☒) d. Future accomplishments
- (☒) e. Relationships to other projects
- (☐) f. Explanation of milestones
- (☐) g. Capital Equipment Request Summary
- (☐) h. Other (Specify Topic)

WORK PROPOSAL REQUIREMENTS FOR OPERATING/EQUIPMENT OBLIGATIONS AND COSTS

Contractor Name: BROOKHAVEN SCIENCE ASSOCIATES/ **BROOKHAVEN NATIONAL LABORATORY**	Contractor Number: 2011-BNL-PO121-Budg	Work Authorization No.: KACH131	Date Prepared: 03/01/2011
Title: LAB 11-438 COLLIDER DETECTOR RESEARCH AND DEVELOPMENT PROGRAM			B&R Code: KA1503020

23. Staffing (in staff years)	Prior Years	FY 2011	FY 2012 President's	FY 2012 Revised	FY 2013 Request	FY 2013 Authorized	FY 2014	FY 2015	Total to Complete
a. Scientific			.10		.10		.10	.10	.40
b. Other Direct		1.61	3.70		3.70		3.70	3.70	16.41
c. Total Direct		1.61	3.80		3.80		3.80	3.80	16.81
24. Operating Expense (in thousands)									
a. Total Obligations		1,706	3,564		3,640		3,675	3,668	16,253
b. Total Costs		1,706	3,564		3,640		3,675	3,668	16,253
25.1 Equipment (in thousands)									
a. Equip Obligations		0	0		0		0	0	0
b. Equip Costs		0	0		0		0	0	0
25.2 Accelerator Improvement Projects									
a. AIP Obligations…..									
b. AIP Costs…………									
25.3 General Plant Projects									
a. GPP Obligations…									
b. GPP Costs……….									

26. Milestone Schedule (Tasks)	Proposed Schedule

Foot Notes:

22. Detail Attachments

a. Purpose

Hadron colliders will provide our major tool to explore the energy frontier for many years to come. However, to provide data sets with sensitivity to the highest mass scales will require a collider running at very high luminosities for a number of years. The particle flux that a detector must deal with at such luminosities provides major challenges in dealing with extreme data rates, in extracting maximum information for triggering, in event reconstruction despite large backgrounds, and in surviving very large amounts of radiation. Two of our major tools for event recognition are charged particle tracking detectors and calorimeters, both of which face major challenges.
This proposal, which has been submitted by a collaboration of 15 institutions, deals with R&D aimed at future detector components in these two areas. Our goals are both significant improvements in performance as well as cost reduction in the very large detectors expected at future hadron colliders.

The goals and the developments described will also provide fundamental contributions to the design of future lepton collider experiments, to large volume imaging devices in long baseline neutrino programs, to space-based experiments and to other basic science fields where high precision measurements are extracted promptly from complex detector systems.

The proposal addresses the following three areas of R&D in tracking systems and calorimeter technology:

- ***Hybrid Pixel Development:*** The general goal of this research's area is to develop pixel systems for applications in high luminosity collider's experiments or, more in general, in experiments with a very high occupancy near the interaction region. The R&D focuses on advancing the state of the art in hybrid pixel technology in order to simultaneously (1) cope with the highest anticipated rate and radiation environments, (2) improve position resolution (which includes reducing material), and (3) decrease the production cost in order to be able to build larger systems, which becomes a necessity as occupancy levels increase.

- ***Development of Novel Modular Tracking Structures:*** Future high luminosity and high energy colliders will require large area tracking devices, with higher granularity, resolution and speed, to provide the experiments with tracking capability in presence of high particle multiplicity and multiple interactions per bunch crossing. The general goal is to develop new low mass high density solid-state tracking structures. The R&D proposed will address issues of system design and operation, scale, integration, manufacturability, materials, and mechanical support needed to develop such a large tracking systems.

- ***Development of New Calorimeter Readout and Trigger Systems:*** This area of research aims at an advance on the state-of-art of the calorimeter readout systems, developing groundbreaking technology for real-time data processing to provide early stage event selection and reconstruction. The R&D program will focus on low power, high performance on-detector analog signal conditioning, fast digitization, very high bandwidth optical modules and tera-scale parallel processing units to extract signal features and trigger primitives in calorimeter applications for experiments at the different frontiers of the high energy physics program.

b. Approach

The R&D activities described in this FWP will be carried by U.S. Physicists collaborating in the ATLAS experiment, one of two major high energy detectors being constructed by the International collaborations for use at the LHC. The following universities will be sub-contracted by BNL in support of this proposal:

University of Arizona,
University of Chicago,
Columbia University (Nevis Laboratory),
Duke University,
University of New Mexico,
University of California Santa Cruz,
Michigan State University,
University of Pennsylvania,
SUNY Stony Brook,
Southern Methodist University,
Yale University

The followings laboratories will be submitting their own FWPs in support of this collaborative effort:
Argonne National Laboratory – FWP no. 50344
Brookhaven National Laboratory – FWP no. 2011-BNL-PO121-Fund
Lawrence Berkeley National Laboratory – FWP no. PH11438
Stanford Linear Accelerator Center (SLAC) – FWP no. 10099

The three areas of research defined in Section a. are organized in WBS structures as shown in Table 1

Table 1: WBS structure for the 3 areas of R&D described in this proposal

WBS Structure for Proposal		
WBS	Name	Institutions
6	Generic Collider R&D	
6.1	Hybrid Pixel Development	
6.1.1	Integrated Circuit Design	LBNL
6.1.2	IC test and irradiation and support for irradiations at the LANSCE facility	LBNL, New Mexico
6.1.3	Sensors and assembly testing and irradiation	UCSC, New Mexico, SLAC
6.1.4	Flex cables, micro-twinax, high speed communication	LBNL, SLAC, UCSC, New Mexico
6.1.5	Development of data acquisition system	SLAC
6.2	Development of Novel Modular Tracking Structures	
6.2.1	Development of thermal-mechanical stave cores and cooling/thermal management	BNL, LBNL, SLAC, Yale
6.2.2	Electrical assembly and test of staves and components	LBNL, UCSC, Duke
6.2.3	Development of multi-channel parallel data acquisition tools, interface and control circuits for stave readout	SLAC, LBNL, Pennsylvania, UCSC
6.2.4	Development and test of alternative powering systems	BNL, LBNL, Pennsylvania, UCSC
6.3	Development of New Calorimeter Readout and Trigger Systems	
6.3.1	Readout architecture and system integration	ANL, Arizona, BNL, Chicago, Columbia, MSU, Pennsylvania, SBU, SMU
6.3.2	Analog signal conditioning and noise optimization	ANL, BNL, Chicago, Pennsylvania
6.3.3	On-detector digitization and data organization	ANL, BNL, Chicago, Columbia
6.3.4	High speed optical links and trigger input solutions	Chicago, SMU
6.3.5	Data organization and processing for presentation to the DAQ system	ANL, BNL, Arizona, MSU, SBU
6.3.6	Calorimeter Trigger Interface	ANL, Arizona, BNL, Chicago, MSU, Pennsylvania, SBU, SMU

Detailed statements of work and resource loaded budgeting sheets for each of the institutions participating can be found in the appendices of the attached full proposal document.

As far as BNL is concerned, it is anticipated that the total numbers of FTE's required for the 5 years of the proposals (FY11-FY15) are shared among the different WBS items as shown in Table 2.

Table 2: Resources required at BNL to support this 5-year program

	FTEs				
WBS no.	FY11	FY12	FY13	FY14	FY15
6.2.1	0.58	1.15	1.15	1.15	1.15
6.2.4	0.28	0.55	0.55	0.55	0.55
6.3.1	0.1	0.4	0.4	0.4	0.4
6.3.2	0.1	0.2	0.2	0.2	0.2
6.3.3	0.1	0.3	0.3	0.3	0.3
6.3.5	0.25	0.7	0.7	0.7	0.7
6.3.6	0.2	0.5	0.5	0.5	0.5
Total FTE's	**1.61**	**3.8**	**3.8**	**3.8**	**3.8**

In the remaining sections of this FWP document the main progress milestones and expected accomplishments in the next 5 FYs are listed for both BNL and all the sub-contracted universities. Progress and expected accomplishments by collaborating laboratories will be included in their corresponding FWPs.
For additional details see the attached proposal document.

c. Technical Progress

Expected Technical Progress in FY 2011

WBS 6.1: Hybrid Pixel Development

- Evaluate susceptibility of available pixel amplifier ASICs to large injected charges on n-on-p sensors
- Submit prototype n-on-p sensor structures with different biasing schemes
- Design and prototype submission for p-type strip sensors with custom sidewalls and study of charge collection at the edge of the device: radiation tolerance and long-term stability studies
- Studies on sustained transmission speeds on available flexible cables (500-1000 Mbps). Studies of the changes of dielectric properties of the bulk material with radiation
- Development and support of the infrastructures and of the irradiation operations (e.g. pre-irradiation characterization, fixture assembly and installation of the stacks, in situ monitoring and measurements, dosimetry) of devices and sensor structures at the LANL proton beam facility. Development of a pion beam program at LANL for irradiation studies
- Comprehensive study of depletion voltage of planar silicon sensors as function of radiation fluence, time, and temperatures, for p- and n-type diodes in Magnetic Czochralski and Float-Zone processing.
- Partnership with industries for single crystal CVD diamond growth processes. Material, radiation tolerance characterization. Studies of new geometries and alternative structures

WBS 6.2: Development of Novel Modular Tracking Structures

- Characterize and simulate a first generation stave core. Begin material characterization studies, develop characterization (QA) techniques, and begin local support development. Build open loop CO_2 cooling system.
- Development and test of the high speed input/output system's (HSIO) firmware and software, using the Reconfigurable Cluster Element (RCE) architecture. Test current version of hardware and iterate on any

- features needed. Most results will pertain to stavelet applications. Design work on HSIO+RCE system. Design and simulation of Hybrid Controller Chip (HCC), completion of high level Verilog description.
- Build a serial powered stave segment ("stavelet"). Assemble test station to run stavelet. Begin system studies. Begin construction of a DC-DC powered stavelet. Submit an initial ASIC (SPP1) designed for serial power control and protection.

WBS 6.3: Development of New Calorimeter Readout and Trigger Systems

- Conduct architecture study for advanced calorimeter readout. Publish the results
- Preamplifier ASIC design and prototyping in IHP SiGe technology. First integration attempt with ADC with the LAPAS preamplifier and shaper prototype.
- Characterize the single-stage converter prototype (Nevis10). Design of rad-tolerant reference voltage circuit and scalable OTA
- Integration test of LAPAS+Nevis10; development of the first full version of a new ADC prototype, based on a previous ASIC project (QIE), designated QIE10C.
- 2-lane serializer and optical link (LOCs2) prototype based on the Silicon-on-Sapphire (SoS) 250nm process by Peregrine.
- First prototype designs for 10 Gbps Advanced Mezzaning Card (AMC) modules for digital data concentrator and processor complete
- Complete first design of Trigger Primitive Builder

d. Future Accomplishments

WBS 6.1: Hybrid Pixel Development

Expected Accomplishments in FY 2012

- Evaluation of first prototypes n-on-p sensor structures with different biasing schemes
- Evaluation of the different encoding schemes on high bandwidth transmission lines
- Continuing studies and characterization of p-type strip sensors with custom sidewalls and study of charge collection at the edge of the device: radiation tolerance and long-term stability studies
- Design and first prototype of specialized fully customized transmission lines.
- Development of the infrastructures and support of the irradiation operations (e.g. pre-irradiation characterization, fixture assembly and installation of the stacks, in situ monitoring and measurements, dosimetry) of devices and sensor structures at the LANL proton beam facility. Development of a pion beam program at LANL for irradiation studies
- Comprehensive study of depletion voltage of planar silicon sensors as function of radiation fluence, time, and temperatures, for p- and n-type diodes in Magnetic Czochralski and Float-Zone processing.
- Partnership with industries for single crystal CVD diamond growth processes. Material, radiation tolerance characterization. Studies of new geometries and alternative structures

Expected Accomplishments in FY 2013

- Second submission of n-on-p sensor prototype structures for testing different biasing schemes
- Transfer technology of p-type strip sensors to pixel devices
- Irradiation tests at LANL of the custom design transmission lines
- Development of the infrastructures and support of the irradiation operations (e.g. pre-irradiation characterization, fixture assembly and installation of the stacks, in situ monitoring and measurements, dosimetry) of devices and sensor structures at the LANL proton beam facility. Development of a pion beam program at LANL for irradiation studies

Expected Accomplishments in FY 2014

- Full-size n-on-p sensor submission with a new protection structure
- Continuing technology transfer of p-type strip sensors to pixel devices. Beam test characterization
- Design and prototype of 2nd iteration specialized fully customized transmission lines.
- Development of the infrastructures and support of the irradiation operations (e.g. pre-irradiation characterization, fixture assembly and installation of the stacks, in situ monitoring and measurements, dosimetry) of devices and sensor structures at the LANL proton beam facility. Development of a pion beam program at LANL for irradiation studies

Expected Accomplishments in FY 2015

- Final evaluation of the n-on-p sensor prototype
- Investigation of industrialization process of p-type pixel technology and second beam test characterization
- Final evaluation and conclusions on the R&D of high transmission rate transmission lines for pixel-based systems in experiments at the future colliders.
- Development of the infrastructures and support of the irradiation operations (e.g. pre-irradiation characterization, fixture assembly and installation of the stacks, in situ monitoring and measurements, dosimetry) of devices and sensor structures at the LANL proton beam facility. Development of a pion beam program at LANL for irradiation studies

WBS 6.2: Development of Novel Modular Tracking Structures

Expected Accomplishments in FY 2012

- Fabricate a co-cured first generation stave core and characterize. Validate simulation models. Prototype support brackets. Initiate industrial contacts for carbon fiber support tube prototyping. Continue material studies.
- Construction and test of a 1st generation full size silicon strip stave. Design and development of 2nd generation silicon sensors.
- Testing and adaptations of HSIO hardware, firmware, and software to readout a full length stave, both sides. Fabrication a number of HSIO+RCE systems, and apply as a stavelet test stand. Submission of first version of HCC chip.
- Perform comparative system studies of serial versus DC-DC powered stavelets. Focus on grounding and shielding issues. Test SPP1 then submit SPP2 that contains additional necessary features. Prototype discrete component 600V HV distribution system.

Expected Accomplishments in FY 2013

- Use simulations to design a second generation lower mass stave core. Begin fabrication. Test prototype support brackets and finish material studies. Prototype carbon fiber support tubes.
- Development of components for a 2nd generation silicon strip stave including service bus cablesand hybrids. Commissioning of hybrid and module assembly tooling and fabrication and test of hybrids and modules using second generation components.
- Adaptation of HSIO and HSIO+RCE system to HCC and ABCn-130 nm chipset. Develop higher speed interface card. Testing with 2nd generation hybrids and modules. Testing of HCC chip, application to hybrids and modules.
- Select powering option based upon previous comparative studies. Begin design and construction of next generation stavelet featuring deep submicron readout ASICs. Test SPP2. Define specifications for a HV control ASIC.

Expected Accomplishments in FY 2014

- Finish fabrication of second generation stave cores and their characterization. Begin simulations and potential prototyping of large scale support. Begin studies of streamline stave-core assembly.
- Construction and test of a 2nd generation stavelet and full size silicon strip stave.

- Testing of HSIO and HSIO+RCE with 2nd generation stavelets and full length staves.
- Test and characterize the next generation stave and stavelet. Fully understand grounding, filtering, and shielding issues. Design SPP3, a radiation hard version of SPP2.

Expected Accomplishments in FY 2015
- Finish research program and document results.
- Continued testing of 2nd generation system, analysis of results, and documentation.
- Continued testing, analysis and documentation.
- Finish research program. The program should have a chosen powering scheme with all grounding, shielding, and system issues understood. Document power, high voltage distribution, and serial power and control solutions.

WBS 6.3: Development of New Calorimeter Readout and Trigger Systems

Expected Accomplishments in FY 2012
- Build prototype cooling system to be used with R&D results of other WBS areas and measure cooling efficiency. Identify one or more point-of-load (POL) power regulators and characterize their performance.
- Prototype testing, decision on technology, and multichannel preamp design, prototyping.
- 4-lane LOC serializer prototyping based on the PC process.
- Complete design of digital part of ADC. Test the QIE10C at the bench chip to characterize the device. perform radiation tests on the new QIE.
- Testing and validating prototypes of 10 Gbps AMC modules for readout processors
- Build and test first complete prototype Trigger Primitive Builder
- Incorporate POL regulators into prototype boards. Measure performance of power distribution. Test with cooling system.
- Multichannel preamp testing and package option studies.

Expected Accomplishments in FY 2013
- ADC prototype chip submitted the final changes to design of the QIE chip and fabricate of order ~50-100 chips.
- Final AMC module prototype and associated firmware, including trigger tower building, complete
- LOC serializer final prototyping, with the PC process or 180 nm technology.
- Build a partition system of the ATLAS calorimeter and test if on mockup by the end of 1^{st} quarter

Expected Accomplishments in FY 2014
- Conduct initial radiation qualification tests of evolving designs from this R&D. Set up and perform tests at at least three irradiation facilities to provide all types of radiation.
- PCB layout for multi-channel preamp. Study noise and crosstalk.
- ADC prototype characterization and integration test with optical link. Instrument ~60 photo multiplier tubes with QIE readout. Design prototype front-end electronics based around the QIE capable of reading out the ATLAS TileCal as a realistic test system.
- Prototypes of the rear transition module to L1, and of the Advanced Telecommunication Computing Architecture (ATCA) carrier board complete.
- Integration of the MUX and the serializer ASIC, packaging option study.
- Install it on the ATLAS detector by the 2^{nd} half of FY 2014.

Expected Accomplishments in FY 2015
- Conduct final radiation testing, power distribution, and cooling tests. Document continuing architectural studies, identifying major options for future colliders.

- Finish Finalized high density PCB layout. Final report on ASIC and PCB development.
- Complete readout chain integration tests. Test of QIE and associated electronics in a test beam at CERN. Publish the results of these tests.
- Final DDCP prototype complete. Final slice tests complete.
- ASIC QA and production readiness review.
- Commissioned during the 2015 data taking at ATLAS.

e. Relationship to other projects

This proposal supports engineers and technicians in the area of interest described in the previous sections. KA1102054 – the U.S. ATLAS Operations Program - also funds in part technical personnel supported by this program. However, KA1102054 focuses on ATLAS upgrade activities ready for installation in 2017-2018, while this FWP addresses longer term generic detector R&D activities for future collider experiments.
Furthermore, at BNL the programs KA1503020, Other Technology R&D Detector Development, KA1102043, LHC Upgrades, and KA1101021, Proton Accelerated Based Exploration of Energy Frontier, are supporting in part or totally those BNL scientists who are principal investigators of this proposal.
University's grants or other core research programs support faculties and scientific personnel from universities sub-contracted through this FWP.

Proposal for Generic Detector R&D for Hadron Colliders

Collider Detector Research and Development Program (LAB 11-438)

Brookhaven National Laboratory

Principal Investigator:

Francesco Lanni
Physicist
Department of Physics, Building 510A
Brookhaven National Laboratory
Upton, New York 11973
Phone: (631) 344-4865
Fax: (631) 344-5078
Email: flanni@bnl.gov

Approving Officials:

Thomas Ludlam
Chair, Department of Physics
Phone: (631) 344-7753
Fax: (631) 344-7142
Email: ludlam@bnl.gov

Howard Gordon
Deputy Chair, Department of Physics
Phone: (631) 344-3740
Fax: (631) 344-5568
Email: gordon@bnl.gov

Requested funding:

FY2011	$1,705,562
FY2012	$3,564,450
FY2013	$3,640,418
FY2014	$3,674,787
FY2015	$3,667,492
Total	$16,252,709

Use of human subjects in proposed project: No
Use of vertebrate animals in proposed project: No

Principal Investigator:		Approving Official:		Approving Official:	
Francesco Lanni	3/15/2011	T. Ludlam	3/16/11	Howard Gordon	3/16/11
Signature	date	Signature	date	Signature	date

Table of Contents

DOE F 4620.1 (04-93) All Other Editions are Obsolete	U.S. Department of Energy **Summary Budget Page**	**Summary** **FY 2011 - FY 2015**	OMB Control No. 1910-1400

ORGANIZATION	Brookhaven National Laboratory			Budget Page No.:	1 of 6
TITLE	LAB 11-438 Collider Detector Research and Development Program				
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Dr. Francesco Lanni				Requested Duration:	54 (months)

A. SENIOR PERSONNEL: PI/PD, Co-Pis, Faculty and Other Senior Associates (List each separately with title; A.6. Show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applicant	Funds Granted by DOE
1. See Budget Explanation Sheet	0.0			$1,703,537	
2. 0	0.0			$0	
3.	0.0			$0	
4.	0.0			$0	
5.	0.0			$0	
6. Others (List individually on Budget Explanation Page)				$0	
7. ( ) Total Senior Personnel (1 - 6)	16.8	0.0	0.0	$1,703,537	
B. OTHER PERSONNEL (show numbers in brackets)	M.m(months)				
1. Post Doctoral Associates	0.0			$0	
2. Other Professional	0.0			$0	
3. Graduate Students	0.0			$0	
4. Undergraduate Students	0.0			$0	
5. Secretarial - Clerical	0.0			$0	
6. Others (List individually on Budget Explanation Page)	0.0			$0	
Total Salaries and Wages (A + B)				$1,703,537	
C. Non Labor Factor				$646,493	
Total Salaries,Wages and Non Labor Factor (A + B + C)				$2,350,030	
D.					
Total Permanent Equipment				$0	
E. Travel 1. Domestic (incl. Canada and U.S. Possessions)				$56,000	
2. Foreign				$126,000	
Total Travel				$182,000	
F. Trainee/Participant Costs					
1. Stipends (Itemize levels, types and totals on budget justification page)				$0	
2. Tuition & Fees				$0	
3. Trainee Travel				$0	
4. Other (fully explain on justification page)				$0	
Total Participants 0 Total Cost				$0	
G. Other Direct Costs					
1. Materials and Supplies See budget explanation sheet for breakdown				$631,500	
2. Publication Costs/Documentation/Dissemination				$0	
3. Consultant Services				$0	
4. Computer (ADPE) Services				$0	
5. Subcontracts See contract breakdown listing by University in the Budget Explanation tab				$10,754,325	
6. Other Organizational Burden & Electric Power				$341,224	
Total Other Direct Costs				$11,727,049	
H. **Total Direct Costs (A through G)**				$14,259,079	
I. Indirect Costs (specify rate and base): Composite G & A Rate of 43.15%. Material Burden rate of 6% on purchase and travel. See Budget Explanation tab for breakdown of rates.					
Total Indirect Costs				$1,993,630	
J. **Total Direct and Indirect Costs (H + I)**				$16,252,709	
K. Amount of any Required cost sharing from Non-federal Sources					
L. **Total Cost of Project (J + K)**				$16,252,709	

DOE F 4620.1
(04-93)
All Other Editions are Obsolete

OMB Control No.
1910-1400

U.S. Department of Energy

Summary Budget Page

Year 1 **FY 2011**

ORGANIZATION Brookhaven National Laboratory

Budget Page No.: 2 of 6

TITLE LAB 11-438 Collider Detector Research and Development Program

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR

Dr. Francesco Lanni

Requested Duration: 6 (months)

A. SENIOR PERSONNEL: PI/PD, Co-Pis, Faculty and Other Senior Associates (List each separately with title; A.6. Show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applicant	Funds Granted by DOE
1. See Budget Explanation Sheet				$153,023	
2.					
3.					
4.					
5.					
6. Others (List individually on Budget Explanation Page)					
7. ( ) Total Senior Personnel (1 - 6)	1.6	0.0	0.0	$153,023	
B. OTHER PERSONNEL (show numbers in brackets)	M.m(months)				
1. ( ) Post Doctoral Associates					
2. Other Professional					
3. Graduate Students					
4. ( ) Undergraduate Students					
5. ( ) Secretarial - Clerical					
6. ( ) Others (List individually on Budget Explanation Page)					
Total Salaries and Wages (A + B)				$153,023	
C. Non Labor Factor				$58,072	
Total Salaries,Wages and Non Labor Factor (A + B + C)				$211,095	
D.					
Total Permanent Equipment					
E. Travel — 1. Domestic (incl. Canada and U.S. Possessions)				$2,000	
2. Foreign				$14,000	
Total Travel				$16,000	
F. Trainee/Participant Costs 1. Stipends (Itemize levels, types and totals on budget justification page) 2. Tuition & Fees 3. Trainee Travel 4. Other (fully explain on justification page)					
Total Participants — Total Cost				$0	
G. Other Direct Costs					
1. Materials and Supplies — See budget explanation sheet for breakdown				$76,500	
2. Publication Costs/Documentation/Dissemination					
3. Consultant Services					
4. Computer (ADPE) Services					
5. Subcontracts — See contract breakdown listing by University in the Budget Explanation tab				$1,173,935	
6. Other — Organizational Burden & Electric Power				$30,651	
Total Other Direct Costs				$1,281,086	
H. **Total Direct Costs (A through G)**				$1,508,181	
I. Indirect Costs (specify rate and base) — Composite G & A Rate of 43.15%. Material Burden rate of 6% on purchase and travel. See Budget Explanation tab for breakdown of rates.					
Total Indirect Costs				$197,381	
J. **Total Direct and Indirect Costs (H + I)**				$1,705,562	
K. Amount of any Required cost sharing from Non-federal Sources					
L. **Total Cost of Project (J + K)**				$1,705,562	

DOE F 4620.1
(04-93)
All Other Editions are Obsolete

U.S. Department of Energy
Summary Budget Page **Year 2** **FY 2012**

OMB Control No.
1910-1400

ORGANIZATION Brookhaven National Laboratory

Budget Page No.: 3 of 6

TITLE LAB 11-438 Collider Detector Research and Development Program

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR

Dr. Francesco Lanni

Requested Duration: 12 (months)

A. SENIOR PERSONNEL: PI/PD, Co-Pis, Faculty and Other Senior Associates (List each separately with title; A.6. Show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applicant	Funds Granted by DOE
1. See Budget Explanation Sheet				$366,162	
2. 0					
3. 0					
4. 0					
5. 0					
6. Others (List individually on Budget Explanation Page)					
7. ( ) Total Senior Personnel (1 - 6)	3.8	0.0	0.0	$366,162	
B. OTHER PERSONNEL (show numbers in brackets)	M.m(months)				
1. Post Doctoral Associates					
2. Other Professional					
3. 0 Graduate Students					
4. ( ) Undergraduate Students					
5. ( ) Secretarial - Clerical					
6. ( ) Others (List individually on Budget Explanation Page)					
Total Salaries and Wages (A + B)				$366,162	
C. Non Labor Factor				$138,959	
Total Salaries,Wages and Non Labor Factor (A + B + C)				$505,121	
D.					
Total Permanent Equipment					
E. Travel 1. Domestic (incl. Canada and U.S. Possessions)				$14,000	
2. Foreign				$26,000	
Total Travel				$40,000	
F. Trainee/Participant Costs 1. Stipends (Itemize levels, types and totals on budget justification page) 2. Tuition & Fees 3. Trainee Travel 4. Other (fully explain on justification page)					
Total Participants	Total Cost			$0	
G. Other Direct Costs					
1. Materials and Supplies — See budget explanation sheet for breakdown				$145,500	
2. Publication Costs/Documentation/Dissemination					
3. Consultant Services					
4. Computer (ADPE) Services					
5. Subcontracts — See contract breakdown listing by University in the Budget Explanation tab				$2,364,146	
6. Other — Organizational Burden & Electric Power				$73,344	
Total Other Direct Costs				$2,582,990	
H. **Total Direct Costs (A through G)**				$3,128,111	
I. Indirect Costs (specify rate and base) — Composite G & A Rate of 43.15%. Material Burden rate of 6% on purchase and travel. See Budget Explanation tab for breakdown of rates.					
Total Indirect Costs				$436,339	
J. **Total Direct and Indirect Costs (H + I)**				$3,564,450	
K. Amount of any Required cost sharing from Non-federal Sources					
L. **Total Cost of Project (J + K)**				$3,564,450	

DOE F 4620.1
(04-93)
All Other Editions are Obsolete

U.S. Department of Energy
Summary Budget Page **Year 3** **FY 2013**

OMB Control No.
1910-1400

ORGANIZATION Brookhaven National Laboratory				Budget Page No.:	4 of 6
TITLE LAB 11-438 Collider Detector Research and Development Program					
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Dr. Francesco Lanni				Requested Duration:	12 (months)
A. SENIOR PERSONNEL: PI/PD, Co-Pis, Faculty and Other Senior Associates (List each separately with title; A.6. Show number in brackets)	DOE Funded Person-mos.			Funds Requested	Funds Granted
	CAL	ACAD	SUMR	by Applicant	by DOE
1. See Budget Explanation Sheet				$380,155	
2. 0					
3. 0					
4. 0					
5. 0					
6. Others (List individually on Budget Explanation Page)					
7. ( ) Total Senior Personnel (1 - 6)	3.8	0.0	0.0	$380,155	
B. OTHER PERSONNEL (show numbers in brackets)	M.m(months)				
1. Post Doctoral Associates					
2. Other Professional					
3. 0 Graduate Students					
4. ( ) Undergraduate Students					
5. ( ) Secretarial - Clerical					
6. ( ) Others (List individually on Budget Explanation Page)					
Total Salaries and Wages (A + B)				$380,155	
C. Non Labor Factor				$144,269	
Total Salaries,Wages and Non Labor Factor (A + B + C)				$524,424	
D.					
Total Permanent Equipment					
E. Travel 1. Domestic (incl. Canada and U.S. Possessions)				$16,000	
2. Foreign				$26,000	
Total Travel				$42,000	
F. Trainee/Participant Costs 1. Stipends (Itemize levels, types and totals on budget justification page) 2. Tuition & Fees 3. Trainee Travel 4. Other (fully explain on justification page)					
Total Participants Total Cost				$0	
G. Other Direct Costs					
1. Materials and Supplies See budget explanation sheet for breakdown				$140,500	
2. Publication Costs/Documentation/Dissemination					
3. Consultant Services					
4. Computer (ADPE) Services					
5. Subcontracts See contract breakdown listing by University in the Budget Explanation tab				$2,411,293	
6. Other Organizational Burden & Electric Power				$76,146	
Total Other Direct Costs				$2,627,939	
H. **Total Direct Costs (A through G)**				$3,194,363	
I. Indirect Costs (specify rate and base) Composite G & A Rate of 43.15%. Material Burden rate of 6% on purchase and travel. See Budget Explanation tab for breakdown of rates.					
Total Indirect Costs				$446,055	
J. **Total Direct and Indirect Costs (H + I)**				$3,640,418	
K. Amount of any Required cost sharing from Non-federal Sources					
L. **Total Cost of Project (J + K)**				$3,640,418	

DOE F 4620.1
(04-93)
All Other Editions are Obsolete

OMB Control No.
1910-1400

U.S. Department of Energy

Summary Budget Page **Year 4** **FY 2014**

ORGANIZATION Brookhaven National Laboratory				Budget Page No.:	5 of 6
TITLE LAB 11-438 Collider Detector Research and Development Program					
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Dr. Francesco Lanni				Requested Duration:	12 (months)
A. SENIOR PERSONNEL: PI/PD, Co-Pis, Faculty and Other Senior Associates (List each separately with title; A.6. Show number in brackets)	DOE Funded Person-mos.			Funds Requested	Funds Granted
	CAL	ACAD	SUMR	by Applicant	by DOE
1. See Budget Explanation Sheet				$394,601	
2. 0					
3. 0					
4. 0					
5. 0					
6. Others (List individually on Budget Explanation Page)					
7. ( ) Total Senior Personnel (1 - 6)	3.8	0.0	0.0	$394,601	
B. OTHER PERSONNEL (show numbers in brackets)	M.m(months)				
1. Post Doctoral Associates					
2. Other Professional					
3. 0 Graduate Students					
4. ( ) Undergraduate Students					
5. ( ) Secretarial - Clerical					
6. ( ) Others (List individually on Budget Explanation Page)					
Total Salaries and Wages (A + B)				$394,601	
C. Non Labor Factor				$149,751	
Total Salaries,Wages and Non Labor Factor (A + B + C)				$544,352	
D.					
Total Permanent Equipment					
E. Travel 1. Domestic (incl. Canada and U.S. Possessions)				$14,000	
2. Foreign				$26,000	
Total Travel				$40,000	
F. Trainee/Participant Costs 1. Stipends (Itemize levels, types and totals on budget justification page) 2. Tuition & Fees 3. Trainee Travel 4. Other (fully explain on justification page)					
Total Participants	Total Cost			$0	
G. Other Direct Costs					
1. Materials and Supplies See budget explanation sheet for breakdown				$158,000	
2. Publication Costs/Documentation/Dissemination					
3. Consultant Services					
4. Computer (ADPE) Services					
5. Subcontracts See contract breakdown listing by University in the Budget Explanation tab				$2,390,835	
6. Other Organizational Burden & Electric Power				$79,040	
Total Other Direct Costs				$2,627,875	
H. **Total Direct Costs (A through G)**				$3,212,227	
I. Indirect Costs (specify rate and base) Composite G & A Rate of 43.15%. Material Burden rate of 6% on purchase and travel. See Budget Explanation tab for breakdown of rates.					
Total Indirect Costs				$462,560	
J. **Total Direct and Indirect Costs (H + I)**				$3,674,787	
K. Amount of any Required cost sharing from Non-federal Sources					
L. **Total Cost of Project (J + K)**				$3,674,787	

DOE F 4620.1
(04-93)
All Other Editions are Obsolete

OMB Control No.
1910-1400

U.S. Department of Energy

Summary Budget Page

Year 5 **FY 2015**

ORGANIZATION Brookhaven National Laboratory

Budget Page No.: 6 of 6

TITLE LAB 11-438 Collider Detector Research and Development Program

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR

Dr. Francesco Lanni

Requested Duration: 12 (months)

A. SENIOR PERSONNEL: PI/PD, Co-Pis, Faculty and Other Senior Associates (List each separately with title; A.6. Show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applicant	Funds Granted by DOE
1. See Budget Explanation Sheet				$409,596	
2. 0					
3. 0					
4. 0					
5. 0					
6. Others (List individually on Budget Explanation Page)					
7. ( ) Total Senior Personnel (1 - 6)	3.8	0.0	0.0	$409,596	
B. OTHER PERSONNEL (show numbers in brackets)	M.m(months)				
1. Post Doctoral Associates					
2. Other Professional					
3. 0 Graduate Students					
4. ( ) Undergraduate Students					
5. ( ) Secretarial - Clerical					
6. ( ) Others (List individually on Budget Explanation Page)					
Total Salaries and Wages (A + B)				$409,596	
C. Non Labor Factor				$155,442	
Total Salaries,Wages and Non Labor Factor (A + B + C)				$565,038	
D.					
Total Permanent Equipment					
E. Travel 1. Domestic (incl. Canada and U.S. Possessions)				$10,000	
2. Foreign				$34,000	
Total Travel				$44,000	
F. Trainee/Participant Costs 1. Stipends (Itemize levels, types and totals on budget justification page) 2. Tuition & Fees 3. Trainee Travel 4. Other (fully explain on justification page)					
Total Participants	Total Cost			$0	
G. Other Direct Costs					
1. Materials and Supplies — See budget explanation sheet for breakdown				$111,000	
2. Publication Costs/Documentation/Dissemination					
3. Consultant Services					
4. Computer (ADPE) Services					
5. Subcontracts — See contract breakdown listing by University in the Budget Explanation tab				$2,414,116	
6. Other — Organizational Burden & Electric Power				$82,043	
Total Other Direct Costs				$2,607,159	
H. **Total Direct Costs (A through G)**				$3,216,197	
I. Indirect Costs (specify rate and base) — Composite G & A Rate of 43.15%. Material Burden rate of 6% on purchase and travel. See Budget Explanation tab for breakdown of rates.					
Total Indirect Costs				$451,295	
J. **Total Direct and Indirect Costs (H + I)**				$3,667,492	
K. Amount of any Required cost sharing from Non-federal Sources					
L. **Total Cost of Project (J + K)**				$3,667,492	

Budget Explanation

A. PERSONNEL

WBS #	Name	Title	Function	FY 11fte	FY 12fte	FY 13fte	FY 14fte	FY 15fte
6.2.1	J. Kierstead	Engineer	Will do gamma irradiations at BNL & arrange proton irradiations at LBNL of mechanical & electrical components for WBS 6.2.1 & 6.2.4	0.03	0.05	0.05	0.05	0.05
	A. Gordeev	Mechanical Engineer	Will perfrom mechanical design & simulation for Stave Mechanical Development	0.15	0.30	0.30	0.30	0.30
	R. Burns	Mechanical Technician	Will perform machining, assembly & stave measurements for Stave Mechanical Development	0.20	0.40	0.40	0.40	0.40
	K. Sexton	Mechanical Technician	Will perform machining, assembly & stave measurements for Stave Mechanical Development	0.20	0.40	0.40	0.40	0.40
			Total FTE's WBS 6.2.1	**0.58**	**1.15**	**1.15**	**1.15**	**1.15**
6.2.4	J. Kierstead	Engineer	Will do gamma irradiations at BNL & arrange proton irradiations at LBNL of mechanical & electrical components for WBS 6.2.1 & 6.2.4	0.03	0.05	0.05	0.05	0.05
	P. Kuczewski	Electronic Technician	Will do circuit design, pcb design, test & measurments and programming for Alternative Powering	0.25	0.50	0.50	0.50	0.50
			Total FTE's WBS 6.2.4	**0.28**	**0.55**	**0.55**	**0.55**	**0.55**
6.3.1	J. Kierstead	Engineer	Work on system integration design, radiation test procedure devpt.,maintenance of radiation testing facility & perform radiation	0.10	0.10	0.10	0.10	0.10
	S. Rescia	Scientist	Work on system integration, front end analog signal conditioning & noise optimization design, testing front end ASIC	-	0.10	0.10	0.10	0.10
	J. Farrell	Design Engineer I	Draft mechanical drawings for system integration & electronics board design	-	0.10	0.10	0.10	0.10
	A. Hoffmann	Technician Research Associate	Implement mechanical infrastructure for test rigs & cooling systems for system integration, perform a radiation qualification test.	-	0.10	0.10	0.10	0.10
			Total FTE's WBS 6.3.1	**0.10**	**0.40**	**0.40**	**0.40**	**0.40**
6.3.2	S. Rescia	Scientist	Work on system integration, front end analog signal conditioning & noise optimization design, testing front end ASIC	0.10	0.10	0.10	0.10	0.10
	A. Hoffmann	Technician Research Associate	Implement mechanical infrastructure for test rigs & cooling systems for system integration, perform a radiation qualification test.	-	0.10	0.10	0.10	0.10
			Total FTE's WBS 6.3.2	**0.10**	**0.20**	**0.20**	**0.20**	**0.20**
6.3.3	H. Chen	Physic Associate 1	Design Readout Drive board & trigger interface board & perform the electroic test of these boards, perform a radiation qualification test.	0.05	0.10	0.10	0.10	0.10
	J. Kierstead	Engineer	Work on system integration design, radiation test procedure devpt.,maintenance of radiation testing facility & perform radiation	0.05	0.10	0.10	0.10	0.10
	A. Hoffmann	Technician Research Associate	Implement mechanical infrastructure for test rigs & cooling systems for system integration, perform a radiation qualification test.	-	0.10	0.10	0.10	0.10
			Total FTE's WBS 6.3.3	**0.10**	**0.30**	**0.30**	**0.30**	**0.30**

WBS #	Name	Title	Function	FY 11fte	FY 12fte	FY 13fte	FY 14fte	FY 15fte
6.3.5	H. Chen	Physic Associate 1	Design Readout Drive board & trigger interface board & perform the electroic test of these boards, perform a radiation qualification test.	0.05	0.10	0.10	0.10	0.10
	J. Mead	Engineer	Design Readout Driver board & trigger interface board & perform the electrical test of these boards	0.10	0.30	0.30	0.30	0.30
	P. Bichoneau	Technical Associate II	Assemble electronics boards & perform electrical test of the Readout Drive board & trigger interface board	0.10	0.20	0.20	0.20	0.20
	K. Ackly	Technican	Draft Readout Drive board layout, generate gerber drawings & photo plot.	-	0.10	0.10	0.10	0.10
			Total FTE's WBS 6.3.5	**0.25**	**0.70**	**0.70**	**0.70**	**0.70**
6.3.6	H. Chen	Physic Associate 1	Design Readout Drive board & trigger interface board & perform the electroic test of these boards, perform a radiation qualification test.	0.05	0.20	0.20	0.20	0.20
	J. Mead	Engineer	Design Readout Driver board & trigger interface board & perform the electrical test of these boards	0.05	0.10	0.10	0.10	0.10
	P. Bichoneau	Technical Associate II	Assemble electronics boards & perform electrical test of the Readout Drive board & trigger interface board	0.10	0.10	0.10	0.10	0.10
	K. Wolniewicz	Technician	Draft Trigger interface Board layout, generate gerber drawings & photo plot.	-	0.10	0.10	0.10	0.10
			Total FTE's WBS 6.3.6	**0.20**	**0.50**	**0.50**	**0.50**	**0.50**
	D. Lynn	Physicist	Will supervise stave mechanical & alternative powering R&D as well as mechanical & electrical design for these projects.	-	-	-	-	-
	F. Lanni	Physicist	Will supervise all WBSs under the calorimeter electronics which includes work on the readout architecture and system integration, analog signal conditioning, on-detector digitization and data organization, data organization and processing for presentation to the DAQ system, and the calorimeter trigger interface	-	-	-	-	-
			Total FTE's WBS 6.2 and 6.3	**1.61**	**3.80**	**3.80**	**3.80**	**3.80**

Salaries are paid at an hourly rate by calendar year.

Salaries are escalated 3.8% annually starting with Year 3

B. Materials and Supplies

6.2.1	5K materials & supplies @ yr. 6K CF license @ yr. 6K 1/2 Ansys License FY 12-15. Low Density carbon fiber pre-preg 10K
6.2.4	Printed circuit board 1.5K @ yr. HV Control ASIC 24K. Materials & Supplies 2-3K @ yr.
6.3.1	FY11 - FY15 Electric parts, develop small test boards, probes for electronics testing,
6.3.2	FY 11- FY 15 Manufacturing of small test boards, purchase compontents for testing of the ASICs
6.3.3	FY 11- FY 15 Purchase components, board manufacturing, cabling for test fixtures
6.3.5	FY 11 - FY 15 Purchase components, board manufacturing, computer software license for FGPA development, probes and development kits.
6.3.6	FY 11 - FY 15 Purchase components, board manufacturing, commisioning of a prototype unit capable of operations at the current front end crate.

B. Materials and Supplies continued

Usual multiplier rate for subcontracts is 16.8%. Special subcontract processing fee will be applied to these contracts at a rate of 4% on direct costs

UNIVERSITY SUBCONTRACTS

WBS	University	Univ PI	FY11	FY12	FY13	FY14	FY15	Total Request
6.1	New Mexico	S. Seidel	63,937	144,420	151,471	158,945	166,149	684,922
	UCSC	A. Grillo	118,815	154,407	160,570	163,426	170,349	767,567
	Pixel subtotal		**182,752**	**298,827**	**312,041**	**322,371**	**336,498**	**1,452,489**
6.2	Yale	P Tipton	20,500	172,000	177,000	179,000	183,000	731,500
	UCSC	A. Grillo	57,383	105,232	108,389	111,640	114,989	497,633
	Duke	M. Kruse	4,000	67,346	68,773	69,988	71,228	281,335
	Penn	B. Williams	101,942	177,437	174,070	154,465	151,713	759,627
	Stave subtotal		**183,825**	**522,015**	**528,232**	**515,093**	**520,930**	**2,270,095**
6.3	Arizona	K. Johns	59,136	116,079	112,095	78,075	117,765	483,148
	Chicago	M. Oreglia	150,100	317,802	325,984	335,296	344,887	1,474,069
	Columbia	i. Brooijmans	201,388	425,630	458,642	426,812	435,148	1,947,620
	MSU	J. Huston	74,500	147,000	152,000	152,000	152,000	677,500
	Penn	B. Williams	72,369	125,800	104,688	107,661	111,225	521,743
	SMU	J. Ye	208,938	322,451	329,069	364,986	313,807	1,539,251
	Stony Brook	J. Hobbs	40,926	88,543	88,543	88,543	81,855	388,410
	Calorimeter Elec.'s subtotal		**807,356**	**1,543,305**	**1,571,020**	**1,553,373**	**1,556,687**	**7,031,741**
	Total		**1,173,933**	**2,364,147**	**2,411,293**	**2,390,836**	**2,414,115**	**10,754,325**

C. Salary and labor burden which are included in the wage pool rate. Non Labor Factor is 37.95% of labor.

D. Capital Equipment None

E. Travel
1 Foreign trip FY 12-15 to Europe(CERN or UK). 1 Domestic trip each year to LBNL to collaborate on stave mechanical R&D.

6.2.1 CERN FY 11-1 trip,FY 12 - 14 2 trips , FY 15 4 trips to attend system integration & radiation testing. 2 trips @ yr. to Boston or LANL

6.3.1 2 trips @ yr. to CERN to discuss progresss of R&D with LAr collaboration. 2 trips @ yr. to Univ. of Penn. or LANL

6.3.2 FY 12 - FY 15 2 trips @ yr. to Boston or LANL for radiation qualification test

6.3.3 CERN FY 11 - 3 trips, FY 12 -14 4 trips, FY 15 5 trips to participate in meetings with European colleagues working on ROD development.

6.3.5 CERN FY 11-12 2 trips, FY 13 3 trips, FY 14 2 trips, FY 15 1 trip to participate in meetings and to evaluate board in situ at CERN

6.3.6 FY 11 1 trip, FY 12 2 trips, FY 13 3 trips, FY 14 2 trips, FY 15 1 trip to collaborate with Dr. W. Cleland at Univ. of Pittsburgh
CERN FY 11 2 trips, FY 12-FY14 4 trips, FY 15 5 trips to evaluate board in situ at CERN

F. Trainee/Participant Costs None

G. Other Direct Costs

Organization burden is assessed on salary to pay for Physics Department administrative costs.

H. Indirect Costs

composite rate

	Year 1 %	**Year 2** %	**Year 3** %	**Year 4** %	**Year 5** %	
BNL Material Burden	6.00	6.00	6.00	6.00	6.00	applied to travel, purchases and subcontracts
Subcontract processing fee	4.00	4.00	4.00	4.00	4.00	applied to subcontract
Electric Power	1.92	1.92	1.92	1.92	1.92	applied to direct salary plus fringe
BNL Common G&A	27.40	27.40	27.40	27.40	27.40	applied to , direct salary plus fringe, organizational burden, purchased goods, material burden, & allocated services
BNL Traditional G&A	8.25	8.25	8.25	8.25	8.25	applied to , direct salary plus fringe, organizational burden, purchased goods, and material burden
BNL LDRD Burden	5.00	5.00	5.00	5.00	5.00	applied to , direct salary plus fringe, organizational burden, purchased goods, material burden, & allocated services
BNL IGPP rate	2.50	2.50	2.50	2.50	2.50	applied to , direct salary plus fringe, organizational burden, purchased goods, material burden, & allocated services
Composite rate	43.15	43.15	43.15	43.15	43.15	

Brookhaven National Laboratory
Project Title: Proposal for Generic Detector R&D for Hadron Colliders
SC Program Announcement Title: Collider Detector Research and Development Program (LAB 11-438)

Investigators:

Maurice Garcia-Sciveres, Lawrence Berkeley National Laboratory
Carl Haber, Lawrence Berkeley National Laboratory
David Lynn, Brookhaven National Laboratory
Larry Price, Argonne National Laboratory
Dong Su, SLAC
Helio Takai, Brookhaven National Laboratory

Principal Investigator:

Francesco Lanni
Department of Physics, Building 510A
Brookhaven National Laboratory
Upton, New York 11973
Phone: (631) 344-4865
Fax: (631) 344-5078
Email: flanni@bnl.gov

Abstract

Hadron colliders will provide our major tool to explore the energy frontier for many years to come. However, to provide data sets with sensitivity to the highest mass scales will require a collider running at very high luminosities for a number of years. The particle flux that a detector must deal with at such luminosities provides major challenges in dealing with extreme data rates, in extracting maximum information for triggering, in event reconstruction despite large backgrounds, and in surviving very large amounts of radiation. Two of our major tools for event recognition are charged particle tracking detectors and calorimeters, both of which face major challenges. This proposal deals with R&D aimed at future detector components in these two areas. Our goals are both significant improvements in performance as well as cost reduction in the very large detectors expected at future hadron colliders.

The goals and the developments described in this proposal will also provide fundamental contributions to the design of future lepton collider experiments, to large volume imaging devices in long baseline neutrino programs, to space-based experiments and to other basic science fields where high precision measurements are extracted promptly from complex detector systems.

This proposal is a collaborative effort led by BNL in conjunction with LBNL, SLAC, ANL, and eleven universities.

Proposal for Generic Detector R&D for Hadron Colliders

Introduction

Hadron colliders will provide our major tool to explore the energy frontier for many years to come. However, to provide data sets with sensitivity to the highest mass scales will require a collider running at very high luminosities for a number of years. The particle flux that a detector must deal with at such luminosities provides major challenges in dealing with extreme data rates, in extracting maximum information for triggering, in event reconstruction despite large backgrounds, and in surviving very large amounts of radiation. Two of our major tools for event recognition are charged particle tracking detectors and calorimeters, both of which face major challenges. This proposal deals with R&D aimed at future detector components in these two areas. Our goals are both significant improvements in performance as well as cost reduction in the very large detectors expected at future colliders.

In the case of tracking detectors we distinguish two challenging regimes. The first is near the interaction region where high granularity is required because of the density of tracks. This is the region where advances in pixel detectors are required. As the volume requiring pixel detectors grows, cost reduction also becomes a primary issue. By choosing a suitably large minimum radius for the remaining parts of the tracker, tailored to the expected luminosity, silicon strip detectors provide good tracking devices. These, however, have to fill very large volumes, providing new challenges on how to build large support structures and how to handle very large channel counts and associated powering issues with a minimum of dead materials that tend to spoil the tracker's performance as well as degrade calorimetry and electron/photon detection. The first two sections of this proposal lay out the R&D which we wish to pursue in the areas of pixel detectors and strip detectors and which we feel will be very beneficial to the particle physics community as a whole. We also note that pixel detectors have broad applications beyond collider detectors and the development of low-mass structures and novel powering techniques can potentially benefit any collider detector. Much effort over a number of years has gone into developing appropriate sensors, partly through the DOE ADR program and the CERN sponsored detector development program. Our goal is to go beyond a number of the sensor issues that have been the focus of previous developments, many of which appear to be in hand, and focus on issues relevant to safe use at very high luminosities as well as cost reduction.

In the area of calorimetry, materials exist that can withstand the radiation expected at hadron colliders (except perhaps at extreme forward rapidities), but the electronics to optimally deal with the information and provide maximum flexibility in triggering from these devices needs to be developed with technologies and components that can withstand the radiation dose. This is an area where the field can benefit from the latest advances in electronics technology for all parts of the data chain from front-end amplifiers to data transmission and reception. Development of suitable electronics will also help the field more generally through the exploration of how to effectively use the most advanced electronics processes. This part of our proposal, which follows the tracker sections, will therefore aim at the development of electronics for both electromagnetic and hadronic sections of the calorimeter chain.

To make it easier to follow the funding requests and the required work, we have organized the proposed effort via a WBS structure. The pixel specific work falls under WBS 6.1, the work on modular tracking structures under WBS 6.2, and the work on new calorimeter electronics under WBS 6.3[i]. Appendix A provides the WBS structure and a summary of proposed budgets by institution. In addition we have

[i] The WBS starts with 6 because of the accounting system of our lead institution.

appendices for the major work areas that outline each institution's plans, budget proposals, budget justifications, and schedules. The appendices are an important supplement to the text.

The proponents for this proposal which is a collaborative effort led by BNL in conjunction with LBNL, SLAC, ANL and eleven universities subcontracted by BNL are members of the ATLAS collaboration at the LHC and therefore bring to the effort many years of experience in developing detectors for hadron colliders as well as working effectively in a collaborative mode. Working on a running experiment also forces us to directly consider the practical aspects of any development. We hope that the R&D of this proposal can yield major physics advances in the hadron collider detectors of the following decade and also benefit future lepton colliders.

We have developed a budget for this work based on our best estimates of what that work would cost, a summary is just below. No physicist salaries are included in this budget, only salaries of technical staff, M&S and travel for the technical staff. However, there are many uncertainties in this budget. We do not know at this time what total budget will be allocated by the DOE for this generic work beyond FY11.

WBS	All Institutions	Level 2 PI	FY11	FY12	FY13	FY14	FY15	Total Request
6.1	Pixel subtotal	M. Garcia-Sciveres	316,124	697,968	1,046,199	1,487,194	1,243,015	4,790,500
6.2	Stave subtotal	C. Haber	582,233	1,531,652	1,473,132	1,582,185	1,430,227	6,599,429
6.3	Calorimeter Elec.'s subtotal	L. Price/H. Takai	1,332,939	2,667,205	2,797,682	3,096,360	2,703,440	12,597,626
	Subcontract processing fee		46,957	94,566	96,452	95,633	96,565	430,173
	Coll Det R&D Program Proposal Totals		**2,278,254**	**4,991,390**	**5,413,465**	**6,261,373**	**5,473,246**	**24,417,728**

Table 1: Collider Detector R&D Program Proposal Budget Totals
The table includes the total cost for the Collider Detector Program Proposal
including those laboratories sending in their own FWPs.

WBS 6.1 Hybrid Pixel Development for Collider Detectors

Among present technologies, hybrid pixel detectors (the integration of IC and sensors) offer the highest radiation hardness, granularity, and rate capability for charged particle tracking. They are therefore presently used as the innermost element of the solenoidal charged particle trackers at the LHC. The achievable position resolution, including multiple scattering due to material, determines the experimental precision of both primary and secondary vertex reconstruction. Primary vertex reconstruction is needed to disentangle multiple interactions, while displaced secondary vertex reconstruction is used to identify *b* quarks and tau lepton decays, both of which are important tools in the identification of decays of new particles beyond the standard model as well as the Higgs boson. This section focuses on advancing the state of the art in hybrid pixel technology in order to simultaneously (1) cope with the highest anticipated rate and radiation environments, (2) improve position resolution (which includes reducing material), and (3) decrease the production cost in order to be able to build larger pixel systems, which becomes a necessity as occupancy levels increase.

Hybrid pixel detector technology has the feature that the readout electronics must cover the entire sensitive surface area given by the sensors. Thus the electronics play a central role in defining the design and characteristics of the entire detector. At the same time, this means that integrated circuit (IC) design and technology can have a dominant impact on all of the goals of this section of the proposal. Continual advances in the consumer microelectronics industry can be exploited to achieve significant gains for future hybrid pixel detectors. Advances in the IC fabrication processes themselves are geared towards ever increasing digital functionality, with staggering processing power possible in just a few microns squared. Equally important are advances in design and simulation tools, which permit a small team of engineers to produce error free circuits with a scale of 100 million transistors. However, both of these technologies are geared towards consumer digital use (such as ever more realistic video games). A main challenge for this proposal is to harness this immense power for mixed signal (analog plus digital) scientific use. In contrast, the radiation sensors needed for particle detectors have no consumer applications and their progress is driven by scientific needs, filled by niche industries. A hybrid pixel detector must combine these two technologies in a harmonious way. Cost reduction, in particular, has very different implications for the IC and the sensors.

Hybridization is currently achieved using fine pitch bump bonding, has been one of the dominant costs of pixel systems. IC design plays a large role in reducing this cost because the cost is per device, not per unit area. Thus, larger IC's reduce this cost. On the other hand, the larger an IC the more challenging the design and yield considerations. The minimum spacing between bumps also influences cost, but once again a uniformly spaced bump pattern (to maximize separation between bumps rather than to follow the circuit layout) is a greater design challenge. Finally, understanding, adapting, and qualifying alternate hybridization methods could also lead to cost reduction, as well as potential performance gains by reducing capacitance.

Beyond the IC, sensor, and hybridization, the technology for combining these components into large assemblies has a large impact on cost, mass, and reliability. It is therefore important to develop the IC and sensor in the context of an electrical system, including power distribution and data transmission. The "integrated stave" model common to both strip and pixel detectors, described under WBS 6.2, will be used for this development, with the focus of this section of the proposal being on the pixel-specific electrical elements. These include interconnection flex cables, power conversion circuitry integrated into the pixel IC, adaptation of data transmission IC's to pixel needs, development of low-mass, high-speed electrical cables (micro-twinax) for interfacing to pixel elements in high radiation environment, mechanically constrained environments, and operation with an advanced high speed data acquisition platform based on modern standards such as Advanced Telecom Computing Architecture (ATCA). The on-chip power conversion will include regulator circuits for serial power, as well as fully integrated DC-DC conversion schemes being developed for the next generation computer processors.

This work will be carried out in the context of international R&D collaborations, as well as with groups outside of HEP that are working in areas where there is technology overlap (for example with the UC Berkeley Engineering Department in the area of on-chip DC-DC converters). The ability to collaborate in this way leverages the investment of any one participant, enabling greater accomplishments. The best example for pixels is the fabrication of readout IC prototypes, which can cost several hundred thousand dollars for a single wafer run, typically out of reach of any single R&D effort.

WBS 6.1.1 Integrated Circuit Design

The proposed development will build on present exploratory work in two technology areas: 3-D electronics integration and 65nm feature size commercial CMOS. Both are possible avenues to achieve smaller pixel size and at the same time more functionality per pixel. The smaller pixel size is needed to achieve higher position resolution, data rates and radiation hardness. The greater functionality necessary for higher rates also enables reduction of power, cost, and services when building larger pixel detector systems. **Figure 1** compares the rate limits of two pixel IC's if placed at a distance of 3.7cm from LHC collisions. The chips compared are FE-I3, which is presently used in the ATLAS pixel detector and was fabricated in 2003, and FE-I4, which is the present state of the art and will be used for the ATLAS IBL (Insertable B Layer) upgrade in 2013[1,2]. The FE-I4 readout IC is the largest format IC fabricated for HEP to date. It uses 130nm feature size CMOS technology. First wafers were delivered in Sept. 2010 and the first production run, to be used for building the ATLAS IBL detector, is planned for late FY11. The FE-14 has two factors which improve performance at higher luminosity: a reduced pixel size (factor of 1.6) and a faster restoration of the baseline for a MIP (factor of 4). The horizontal axis of **Figure 1** is a measure of the instantaneous rate: the number of interactions per bunch collision expected at the given collider. A goal of this proposal is to achieve efficient operation up to values of at least 400 on this scale. The vertical axis shows the inefficiency (hit loss) resulting from high rate. The dashed lines show the effect of hits overlapping in the same pixel within a short time, which is the main reason for reducing pixel size. The solid lines show the effect of adding processing inefficiencies - not enough circuit capacity, such as memory, for the volume of hits received. More functionality per pixel is needed to improve upon this. It is worth noting that the FE-I4 chip, representing the present state of the art, is the product of generic technology exploration done in 2005-2007, followed by targeted development started in FY2008.

The goal of this development is to arrive at a working chip that will define the new state of the art by the end of the proposal period. It will be necessary to fabricate and evaluate small prototypes in both candidate technologies, 3-D and 65nm CMOS, select one, assemble an international design team, and carry out the design of a full size device. The evaluation of prototypes will involve irradiations of various kinds, with proton total dose runs included in this proposal. 3-D and 65nm each have their advantages and drawbacks. With 3-D integration it is clear that one can multiply the amount of circuitry in a given pixel by stacking multiple layers, while keeping the ability to choose the transistor feature size for other reasons than circuit density, such as analog performance and cost. However, 3-D is not yet a fully qualified production process available to end users with a full suite of design tools. On the other hand, a conventional 2-D circuit in small feature size, such as 65nm, offers a stable, production process with highly sophisticated design and simulation tools. But the feature size must be fixed by the needed circuit density. **Figure 2** shows the circuitry in a pixel of the present FE-I4 chip, and how it can be naturally split into two tiers of a 3-D chip, thus cutting the pixel size in half. **Figure 3** shows an exploratory 65nm layout inside the outline of an FE-I4 pixel, showing the dramatic size reduction possible. Under this proposal, we will collaborate with a European 3-D consortium[3] that will play the lead role in the 3-D design effort. This is part of the 3-D multi-project run program organized by Fermilab. We will play the lead role in the 65nm design effort, aiming to build an international collaboration following the FE-I4 experience.

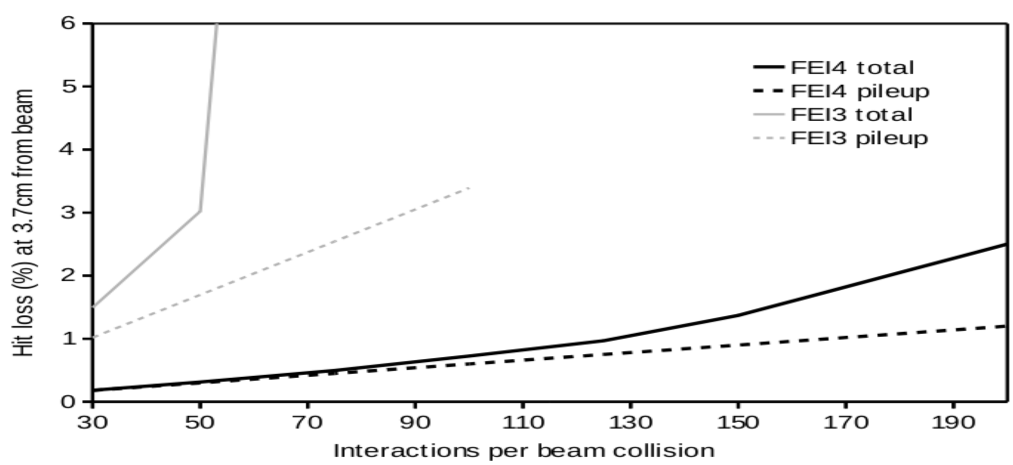


Figure 1: Comparison of rate limits of the FE-I3 and FE-I4 chips.

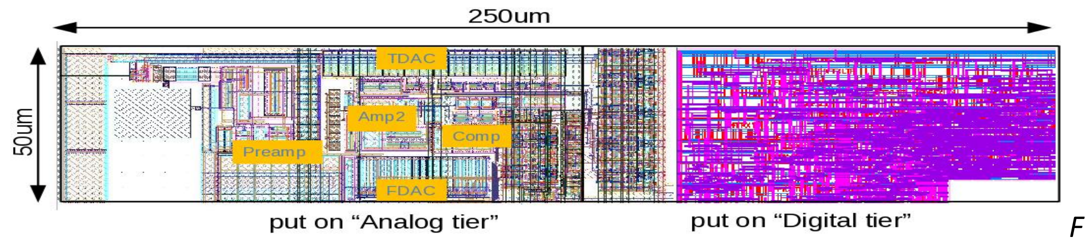


Figure 2: Circuitry of one FE-I4 chip pixel, with indication of how to divide it onto two tiers of a 3D chip.

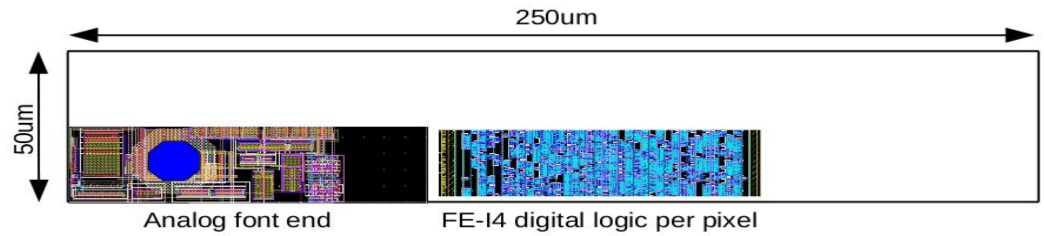


Figure 3: Pixel circuit layout in 65nm feature size, shown inside outline of one FE-I4 pixel. The digital logic shown is the FE-I4 high level description synthesized using a 65nm library.

WBS 6.1.2 IC Test and Irradiation Facilities

When using commercial IC technologies that were not designed for and are not rated for radiation tolerance, systematic monitoring of radiation hardness is critical. Any changes with radiation must be understood at least empirically and fed back to the design. The number of facilities around the world that can deliver the required doses with ionizing particles while allowing for electrical operation during exposure is very limited. The LANL Neutron Science Center (LANSCE)[4] is one such unique facility to which we have access (for both sensor and IC characterization). We propose to strengthen our program at this facility, supporting multiple runs per year.

WBS 6.1.3 Sensor and Assembly Testing and Irradiation

Because hybrid pixel technology is based on intimate sensor-readout chip integration, one cannot develop chips or sensors in isolation from one another. Pixel sensor R&D is a very active field, with large collaborations that have large non-US participation. All commercial silicon sensor manufacturers are abroad. This proposal includes testing of sensors and modules (sensor + chip assemblies). We largely expect to receive such sensors and module assemblies from our international collaborators, and to participate in the testing and specification of new sensors. In addition to sensor testing work within international collaborations, we propose to carry out a unique technology development on two critical areas: edge design of low cost sensors for large pixel systems, and protection for catastrophic events, also critical for large systems.

The limits of sensor radiation hardness, necessary for operation within a few cm of high intensity future colliders, are being investigated by the international collaborations RD50 for silicon and RD42 for diamond. We propose to continue our participation in both these efforts. We will provide testing facilities and expertise for depletion voltage characterization and comparison between sensor types. In addition, we propose to participate in the development of a new pion beam capability at LANSCE, motivated by sensor characterization needs. The ability to irradiate with pions as well as protons is an important feature to aid our understanding of sensor radiation damage mechanisms.

The n-on-p planar sensor configuration is the most promising pixel and strip technology for covering large areas with pixel detectors, thanks to the lower manufacturing cost of single-sided wafer processing and ease of thickness control on 6 inch format wafers, in addition to good radiation tolerance and annealing behavior[5]. However, the peripheral region of the n-on-p sensors must be occupied by guard rings and extra space to account for damage caused by saw cuts. This region is inactive. It contributes extra material budget, and reduces hit efficiency per-area. Additionally, the edge of the sensor is typically conductive due to the sidewall damage in wafer dissection. This leads to a situation where the backside potential is conducted over to the top surface, near the readout ASIC and introduces a possibility for detrimental sparking. We propose to attack these problems by making a special edge, which has much more inert properties than the one made by a saw cut or other methods incurring sidewall damage. This should allow minimization or complete removal of the guard rings leading to much narrower inactive edges. The inert sidewall we are exploring might accept some potential gradient thereby alleviating this concern. An alternate approach, if necessary, would be to explore additional passivation of the top surface with dielectrics such as Kapton.

Module assemblies, required for understanding the combined performance of chips and sensors, will be based on the FE-I4 chip for the initial years of this proposal, as this will remain the most advanced full size pixel chip available for some years to come. Our module R&D will focus on communication (discussed under WBS 6.1.5), power distribution, and safe operation. The main interest in power distribution is in the design of on-chip DC-DC conversion circuits for future pixels chips (the existing FE-I4 chip already includes a rudimentary internal DC-DC converter). Tests of module operation with various power distribution arrangements will inform this design work. Part of these tests will involve integration of modules onto support structures (covered under pixel and stave mechanics) with integrated electrical cables, also described below under WBS 6.1.4.

Pixel detectors are designed to work with very small signals. However, in rare cases (e.g., beam loss), the instantaneous incident radiation can be many orders of magnitude larger than typical. Very large signals could damage the sensor or the input amplifier, making the understanding of these rare events necessary for safe operation of large systems. The pixel sensors at the innermost layers are more likely to experience such events. We propose to systematically investigate the options for dealing with scenarios of charged particle fluxes many orders of magnitude greater than typical. This involves evaluation of the performance of the currently available front-end amplifiers and sensors, and development of custom pixel biasing schemes. The latter can be represented by, e.g. punch-through or bias resistor techniques with possibly quite different damage susceptibility. Development of the best technique is not trivial due to the small amount of space allotted to the layout of an individual pixel. The results of the pixel bias optimization would feed into the specifications for future front-end amplifiers.

WBS 6.1.4 Flex Cables, Micro-Twinax, and High Speed Communication

Just as it is not possible to develop readout chips in isolation from sensors, the electrical system that the modules are part of must be understood in parallel with the chip and sensor design. The integration of electrical services into the mechanical structures, developed in the stave section of this proposal, must be supported by electrical design work closely coupled to the electronics. Under this WBS element of the proposal we will focus on data transmission from the modules out. Within the support structures the data from multiple chips must be aggregated into high speed links for efficient, low mass transmission off detector. The data links integrated into the mechanical supports will be based on flexible printed circuits. Additionally, the goal for a minimum mass pixel system is to include functionality for data aggregation in the readout chip itself, rather than requiring additional components. A robust mechanism for such aggregation must be developed.

High speed data transmission over distances of order 100m or more is suited for optical communication. However, the placement of optical drivers within pixel systems (at the ends of the module support structure, for example) has significant problems. Space is limited at low radius such that optical components would have to be miniaturized. Routing of optic fibers has greater restrictions than routing cables, which would complicate the mechanical design (adding mass). Radiation is high at small radius (one of the reasons pixels are used in the first place), which is a problem for optical components. Finally, reliability is reduced because components embedded in a pixel system would not be accessible. For all these reasons we propose a further development of high speed transmission on low mass coaxial cables. This is not intended as a solution for distances of order 100m, but rather to decouple the placement of the optical components in a pixel system from the point at which data must be serialized onto high speed links. This allows optimizing the placement of optical components within a few meters for low mass, high reliability, and ease of detector assembly. **Figure 4** shows a diagram of the data transmission scheme to be developed in this proposal. The technologies needed are data aggregation within a module, intermediate speed transmission on flexible printed cables (including prototyping of such cables to provide to the stave development effort), and high speed transmission over "twinax" cables (a differential coaxial format). We propose to combine the data for multiple modules onto high speed twinax links using the CERN developed GBT system[6]. GBT prototypes are under development and will soon be available, but interfacing with twinax cables that we propose is not part of the CERN development plan.

We have already performed proof of principle demonstrations of transmission at 320 Mbps with point-to-point links on Kapton cables using LVDS signals. We will further this work to demonstrate reliable operation in a realistic system with pixel modules and GBT components. 320 Mbps may be sufficient for large radius layers in future collider detectors. However, the data rates closer to the interaction point could reach 500-1000 Mbps rates based just on expected track density per unit detector area. These high rates are in the frequency regime where dielectric signal losses become important, in addition to the transmission line effects that dominate at lower frequency due to inductance and the skin effect. We anticipate, therefore, that simple verification of the correct data transmission might be insufficient. In this case additional possibilities should be explored, such as different data encoding schemes, pre- and de-emphasis, as well as cable geometry optimization. We propose to explore the bandwidth limits of typical low mass cables (e.g., copper or aluminum on Kapton), test potential improvements from various encoding and signal shaping techniques, and investigate other novel cable technologies to determine the optimum techniques for data transmission for pixel detectors operating in high track density environments. Irradiation tests will be necessary since cable material properties such as dielectric losses could change significantly with radiation.

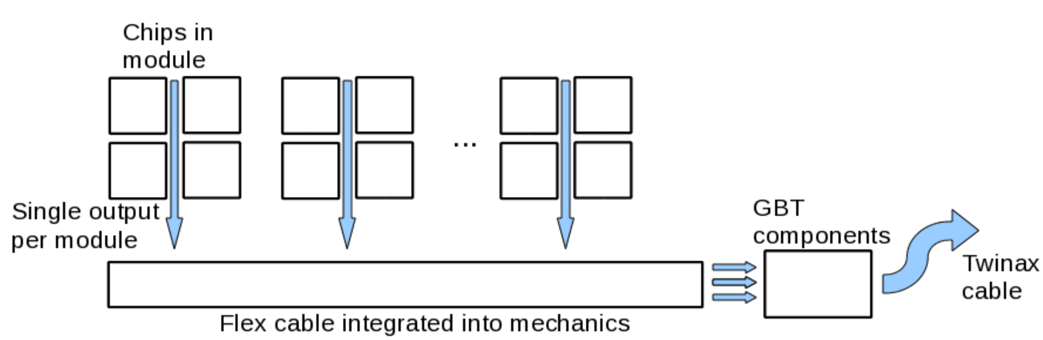


Figure 4: Diagram of data transmission concept to be developed in this proposal.

WBS 6.1.5 Development of Data Acquisition System

The readout needs from single chip tests, to full stave level multi-channel systems and test beams can all leverage the high bandwidth generic DAQ R&D originated at SLAC with the Reconfigurable Cluster Element (RCE) concept on the ATCA platform, including the extensive associated software utilities that exist. Only moderate additional effort for interface design and fabrication, and test software specific to this proposal will be required to serve all test needs.

Institutional Roles

We list below a brief list of institutional responsibilities. A much more detailed work plan as well as budgets can be found in Appendix B.

WBS 6.1.1 Integrated circuit design. LBNL: Implementation of pixel readout circuits in 65nm feature size CMOS, as well as in 130nm feature size 3-D integrated circuits. These activities will be in collaboration with international partner institutes and other non-HEP partners such as UC Berkeley Engineering. Includes integrated power conversion circuitry.

WBS 6.1.2. Integrated circuit test and irradiation. LBNL, SLAC, New Mexico: bench testing of prototype bare circuits. Irradiation at Los Alamos Neutron Science Center, lead institution is UNM.

WBS 6.1.3. Sensor and module test and irradiation. UC Santa Cruz, New Mexico, SLAC: bench testing bare sensors, chip + sensor assemblies, irradiation at Los Alamos Neutron Science Center and elsewhere, test beam characterization at SLAC test beam facility and elsewhere.

WBS 6.1.4. Flex cables, micro-twinax for data transmission, high speed communication and DC-DC conversion. LBNL, SLAC, UCSC: design, fabrication, and testing of flex and twinax cables. Testing of cables and assemblies including modules and stave local supports. Testing of communication using high speed interface chips such as the CERN GBT system.

WBS 6.1.5. Data acquisition in support of above tests. SLAC: development of interface boards and software for readout of new IC and module prototypes using the ATCA platform. Note that development of the ATCA based DAQ platform itself for large scale (full experiment) data acquisition is beyond the scope of this proposal. We are aware that a separate proposal is being submitted to cover such DAQ development.

WBS 6.2 Development of Novel Modular Tracking Structures for Collider Detectors

For charged particle tracking at a future high luminosity and high energy hadron collider, a large, all-solid-state tracker will likely be required. From a physics perspective, such a system would provide the requisite granularity, resolution, and speed to support tracking in the presence of high particle multiplicity and multiple interactions per crossing. This large tracker should also introduce minimal material into the active regions in order to not degrade overall detector performance. From an engineering perspective, solid-state position sensitive detectors are an obvious choice due to their inherent speed, segmentation, radiation hardness, and technological maturity. At the state-of-the-art today are the large tracking systems at the LHC. None of these would, however, meet the specifications for a future high luminosity collider. What will be needed are more granular detectors, with significantly better radiation hardness and overall less material. The R&D we are proposing will address issues of system design and operation, scale, integration, manufacturability, materials, and mechanical support needed to develop such a large tracker for the future. Within this R&D collaboration are groups with extensive experience, which we bring to the proposed effort, from the construction, installation, and operation of the present generation of LHC trackers.

Stave Based Tracking Detectors

For the existing LHC trackers a basic building block was a "sensor-readout module". As an example, in the ATLAS detector the silicon strip module was an item of roughly 10 x 10 cm^2, powered and accessed by a dedicated cable plant. The ATLAS detector contained some 4000 such units, each individually mounted and serviced. In order to build a much larger tracker within a similar timeframe, with similar or reduced amounts of material, and for a reasonable cost, early and aggressive integration of components is a powerful approach. Therefore, this R&D will focus on highly integrated systems referred to as "staves", which contain many modules, pre-assembled into a single structure. Staves can be applied both to pixel and silicon strip trackers. Stave examples and components are illustrated in **Figure 5**. A similar concept can be applied in the forward regions of a tracker through the use of disk-segment elements.

As envisioned here, a stave is built upon a low-mass mechanical core composed of carbon-composite-based materials with enhanced stiffness and thermal conductivity. Embedded cooling tubes within the core carry evaporative coolants, such as CO_2 or a fluorocarbon. Service cables (thin etched flexible circuitry) and multiple sensor-plus-readout-electronics "module" packages are located precisely on the mechanical core. Staves will also require advanced powering systems such as serial current or DC-DC conversion, multiplexed HV distribution, and large parallel multi-drop trigger, timing, and control networks in order to dramatically reduce the cabling material. At one extreme, a single double-sided 1.6 meter long stave, aimed at relatively large radius tracking, may carry the equivalent of 32, 10 x 10 cm^2 modules, where each module could be further subdivided on a given sensor into 2-4 longitudinal tracking segments. At small radius, pixel staves, of lengths of 1-1.4 meter could carry 25-40 individual pixel module units. Because the stave is highly integrated, it can make optimal use of components and offers a clear advantage both in thermal performance and in material radiation lengths, as compared to a design based upon individual modules. In the construction of a large tracker, the stave offers a way to front-load much of the precision assembly and testing steps and therefore simplify and expedite the final installation and commissioning of the full system.

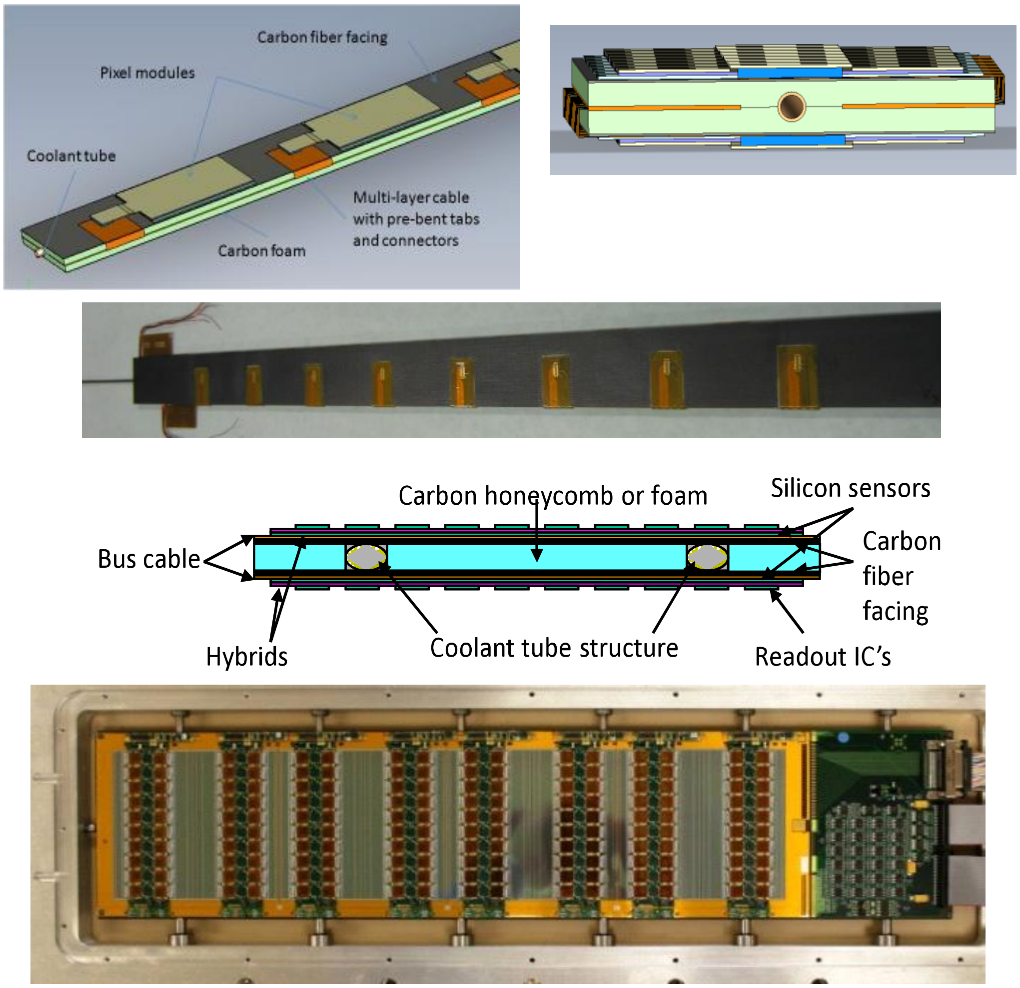


Figure 5: Examples of stave structures built up of sensor-readout modules laminated on high-stiffness and high thermal conductivity carbon composite cores. Top left drawing shows a pixel stave with modules placed in alternating positions on both sides. Top right is a cross section with a cooling pipe embedded in a high performance carbon foam core, coplanar with metal-kapton electrical cables for module powering, readout and control. Second from top is a photograph of a prototype of such a structure. Third from top is a cross section of a 12 cm wide silicon strip stave. This contains a cooling loop, again embedded in a foam or honeycomb structure between carbon fiber facings. Electrical bus work is laminated on the outside, top and bottom, with sensor modules fully covering both faces (either in an axial-axial or axial-stereo arrangement). Bottom photograph shows a fully functional electrical "stavelet", one third length, built for electrical and powering studies. This stavelet is serially powered and interfaced though an end-of-stave card seen at the right of the image.

Early examples of this integrated approach are the CDF Run2b staves[7] and the CMS "ROD" structures[8]. The pixel detector of the present ATLAS tracker utilized a simple one sided stave structure[9]. The present research proposal goes substantially beyond these. The systems studied here are larger in scale, more highly integrated, operate at lower temperatures, are alternatively powered, and utilize new and more advanced thermal materials. They must also meet much more demanding performance and reliability requirements under intense irradiation. The technical challenges and risks posed by these innovations require a focused and dedicated generic research effort in the near term.

The research program proposed here will address a variety of issues, both for pixel staves at small radius and for silicon strip staves, extending to the outermost regions of the tracking volume. For tracking in the forward/backward direction, the stave generalizes into a tapered structure, referred to as a petal, which forms a segment of an annular ring. Most technical aspects are common to staves and petals and both are considered here.

This R&D proposal grows out of an on-going, international program to develop the integrated stave concept and we plan to remain engaged collaboratively with international groups having related interests. Consequently there is considerable technical basis already behind the efforts proposed here and a number of items can be cost shared with non-US groups. A summary of some recent developments in the on-going program is given in Appendix E. Some of the development effort will also be subcontracted to private firms with particular expertise in order to foster industrial development.

Staves also offer an advantage for advanced silicon strip tracking detectors which include fast "Level-1" track triggering[10]. Because the stave has a natural radial width of a few millimeters, local transverse momentum correlations can be found with appropriate on-module electronics included as part of the front end readout. While such trigger developments are beyond the scope of this proposal, the work here forms a necessary basis to further developments in this area as well.

While the stave/petal R&D proposed here is motivated by the requirements for future high luminosity hadron colliders, it may apply as well to other areas of research where low mass/material precision support, high channel count, and integration are of value. For example, some of the research proposed here has a precursor in developments of carbon composite structures for earlier trackers at hadron colliders. Since that time, the relativistic heavy ion physics community in the USA has adopted this approach for the construction of a number of tracking upgrades at the RHIC facility[11].

The timescale proposed here, beginning in FY2011 and extending through FY2015, covers a "two generation" research and development effort. The work during the period FY2011-2012 should result in full scale prototypes of many components, which enable various technical choices to be explored. In the period FY2013-2014 second generation components and staves will be fabricated and tested based upon the results of the prior studies. In FY2015 any additional iterations and testing, final analyses and documentation will occur.

There are four key research areas in this program and they are summarized here and then expanded upon. Full statements of work for each institution are given in Appendix C.

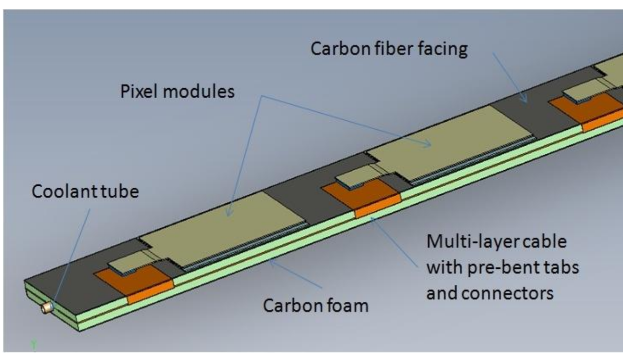
- **WBS 6.2.1 Stave Mechanical:** The goal is the development of new carbon-based components, structures and cooling to achieve thermal mechanical support, which minimizes radiation length while meeting requirements on stiffness, precision, manufacturability, thermal performance and radiation resistance. Prototype pixel and strip structures will be designed, simulated, fabricated, and tested, both thermal-mechanically and as part of electrical staves.
- **WBS 6.2.2 Stave Electrical:** Development of service and module integration well beyond methods used in existing trackers. Electrical sensor-readout modules and associated circuitry and services will be developed and assembled into functional staves. These developments will stress both performance and manufacturability.
- **WBS 6.2.3 DAQ and Control:** Development of highly parallel data acquisition and control tools to enable simultaneous operation and readout of fully populated stave/petal structures. This includes interface circuitry to enable flexible addressing of the numerous front end readout chips.
- **WBS 6.2.4 Powering:** Development of alternative powering and HV systems including serial power and DC-DC conversion circuits specific to the power requirements and system aspects of large silicon strip staves. These will be tested on electrical stave/petal structures. Aspects of slow control, monitoring, and failure tolerance will be addressed. This R&D should inform the technical selection of an optimized powering scheme.

WBS 6.2.1 Stave Mechanical

The mechanical aspects of this proposal will address different issues relevant to pixel and silicon strip trackers. Pixel detectors function at smaller radii and present the greatest challenges with respect to thermal performance, mass reduction, and radiation hardness. Strip detectors function at medium to large radii and therefore cover very large areas. For this region, long, stable structures are required which can be fabricated in a large scale, economical process. Relating to both pixels and strips is the choice of coolant. Practical considerations which suggest a common solution for all radii must be weighed against other engineering and technical aspects such as pressure and pipe design. Tests need to be conducted with new candidate coolants and realistic delivery systems.

WBS 6.2.1.1 Pixel Detector Mechanics

For applications to future pixel detectors, this R&D program will focus on the use of a new material– low-density, thermally-conducting carbon foam – as the basis for low-radiation length mechanical supports with integrated cooling and electrical services. The development of this new foam material is underway and has been funded by the DOE SBIR program.[ii] The foam material is produced in blocks (up to 30cm x 30cm x 2.5cm at this time), can be readily machined into complex shapes, has a thermal conductivity of 30 – 40 W/m-K (for density ~ 0.22 g/cc) and has adequate compressive and tensile strength to form rigid structures. The foam material may be combined with different types of carbon fiber materials to create a variety of structures to support and cool pixel detector modules, and the structures can be configured to include highly integrated electrical connections to power and read out modules. For the highest power applications and the use of silicon detectors in an intense radiation environment, evaporative CO_2 cooling using titanium pipes would be used. Other coolants and pipe materials are possible for other applications. An example concept for a stave structure appropriate for a large-area pixel detector is shown in **Figure 6** (left). A section of a prototype "coupled-layer" structure appropriate for the inner layers of a collider tracker is shown in **Figure 6** (right).



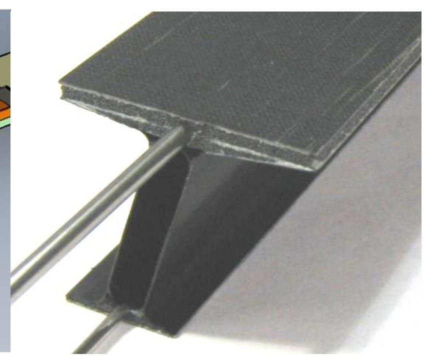


Figure 6: (Left) Concept for large stave to hold pixel modules based on carbon foam and high quality carbon fiber with an embedded cooling tube and metal-kapton electrical cables for module powering, readout, and control. (Right) An example of an "I-beam" structure for inner tracking layers also using foam and different carbon fiber materials. Pixel modules would be mounted on the top and bottom flat faces of this structure. Electrical cables would be glued to the web between layers and make connections with tabs, similar to the figure shown on the left. The goal is to minimize the total material.

The properties of the foam material have been measured in a preliminary way but substantial work remains to characterize this new material and understand the impact of manufacturing variations. Prototypes have been constructed and tested thermally and mechanically, including with CO_2 cooling. Preliminary results indicate that the design concept is robust. Extensive thermal cycling and irradiation of

[ii] Phase II SBIR, Thermally Conductive, Carbon Foam Material for Constructing Silicon-Based Detector Structures, Allcomp Incorporated 209 Puente Ave City of Industry, CA 91746

a few structures up to 1 GRad have been done. Mechanical assembly of structures with embedded electrical cables has been done but electrical readout of pixel modules has not yet been done. Small prototypes of non-planar (bent) structures have been made and concepts for disks have been developed but not fabricated. The overall conclusion is that combining the carbon foam, carbon fiber, coolant pipes and electrical services into a highly integrated, modular structure is a very promising approach to future pixel trackers.

The proposed development path over the next 4-5 years has a number of essential components. #1: Continue the development and characterization of the foam material in collaboration with industry. Although substantial progress has been made, there are variations in thermal and mechanical properties from piece to piece that are not understood. In addition, there may be ways to further enhance both the thermal conductivity and the strength. #2: The fabrication and test (thermal performance, deflection, stability, etc) of prototypes of different structures that match the needs for different regions of future trackers. #3: Reliability testing (thermal cycling, irradiation and handling), is critical for any design. #4: Measurement alone is not sufficient and detailed modeling of thermal and mechanical performance is essential. The foam is intrinsically difficult to model in detail (on the scale of the cell structure) and substantial work is needed, taking advantage of academic and industrial work on modeling of foams. #5: It is essential to continue efforts to reduce the radiation length of the structures. This will require working with the foam manufacturer to achieve the same thermal conductivity and strength but at lower density and working with carbon fiber vendors to produce low areal-weight fiber prepreg with high in-plane (and adequate out-of-plane) thermal conductivity. We also propose development of adhesives (to attach a cooling pipe to foam and foam to carbon fiber) with improved thermal conductivity, replacing boron-nitride fillers with carbon nanotube fillers. A possible approach in some applications is to eliminate some of the carbon fiber, coat the foam (e.g. with SiC) and directly attach modules to the foam. We also propose to construct a closed loop CO_2 cooling system and use it to perform a variety of thermal mechanical tests of staves related components. All of these R&D goals would be addressed in a coherent program by this proposal.

Short Statement of Work and Milestones: This is an LBNL and SLAC activity.

2011: Fabricate prototypes and test them using previously obtained foam and carbon fiber material. Perform thermal and structural simulations to compare with measurements. Design and begin fabrication of closed loop CO_2 cooling system.

2012: Procure low areal weight carbon fiber material, the latest foam material from Allcomp, Inc and new adhesives. Prototypes would be fabricated, tested and analyzed. Complete CO_2 cooling system develop control and monitoring aspects.

2013: Mechanical prototypes would continue to undergo thermal cycling, be exposed to very high doses of Co^{60} gamma rays and analyzed. Testing of a prototype instrumented with pixel modules would be a significant goal. Development of means for direct module attach to foam. Measurements with CO_2 system.

2014: Consolidate R&D approaches into a few concepts that meet the needs for all regions of a future tracker. Build full-scale prototypes, continue reliability and thermal/cooling testing and analysis

2015: Prototype fabrication and testing would be completed. Analyses would be documented.

WBS 6.2.1.2 Silicon Strip Trackers at Intermediate and Large Radius

For silicon strip trackers at intermediate and large radii, the stave cores must be larger, cheaper and more amenable to mass production than cores for pixel regions. The design of the stave cores must be considered concurrently with that of larger support structures that support many staves at a given radius. This is necessary as there is an optimization required between mass in the stave cores vs. mass in the large support structures that delivers sufficient stiffness while minimizing overall mass. Thermal performance of the stave core which depends upon integrated radiation levels as well as expected power performance of next generation sub-micron readout ASIC technologies must also be understood.

The silicon strip stave mechanical R&D program will include the following:

- In collaboration with the pixel mechanics effort, characterize low mass composite materials including carbon foams, thermal epoxies, and low areal density carbon fiber sheets.
- Prototyping of stave cores to test assembly methods and characterize thermal and mechanical performance. Included will be attempts to co-cure kapton circuits with carbon fiber sheets.
- Developing QA techniques such as resonant frequency characterization and convective heating of stave cores that serve to benchmark performance as well as to validate simulations of the stave cores; these techniques may later find application in stave core production lines.
- Development of simulations that will be compared to built prototypes; validation of the simulations will permit their use to examine a larger variety of stave core options than can be cost effectively prototyped. Utilization of CO_2 cooling test stands.
- Simulations of larger support structures to understand performance of the overall mechanical support system.
- Irradiation of materials and small prototypes to verify radiation hardness.

Short Statements of Work and Milestones:

2011: Characterize and simulate a first generation stave core. Begin material characterization studies, develop characterization (QA) techniques, and begin local support development. Build open loop CO_2 cooling system. BNL, SLAC, Yale.

2012: Fabricate a co-cured first generation stave core and characterize. Validate simulation models. Prototype support brackets. Initiate industrial contacts for carbon fiber support tube prototyping. Continue material studies. BNL, Yale, LBNL.

2013: Use simulations to design a second generation lower mass stave core. Begin fabrication. Test prototype support brackets and finish material studies. Prototype carbon fiber support tubes. BNL, Yale, LBNL.

2014: Finish fabrication of second generation stave cores and their characterization. Begin simulations and potential prototyping of large scale support. Begin studies of streamline stave-core assembly. BNL, Yale, LBNL.

2015: Finish research program and document results. BNL, Yale, LBNL.

WBS 6.2.2 Staves Electrical

The electrical R&D of this proposal will focus on the fundamental issues of sensor-readout performance within a tightly integrated stave system. By fabricating and mounting a significant number of sensor-readout units on staves and stavelets (shorter stave sections) noise, pickup and interference, grounding and shielding, and signal and power distribution effects will be studied. Through these studies the performance margins and the limits of material and services reduction will be analyzed. By fabricating and mounting large numbers of sensor-readout units, considerable experience will also be acquired in handling, mounting, and testing these units. These tasks will be distributed across the collaboration. Various stave electrical components will be fabricated and tested as well.

Short Statements of Work and Milestones: This WBS item is an LBNL, UCSC and Duke activity.

2011: Complete ongoing studies of serial and DC-DC powered stavelets. Analysis and comparison of powering options based both upon bench test results and system issues including material, reliability, and control. Commissioning of hybrid and module assembly tooling and fabrication of hybrids and modules. Testing of multi-drop signal distribution. Development of service bus cables for various options (powering, grounding, shielding).

2012: Construction and test of a 1st generation full size silicon strip stave. Design and development of 2nd generation silicon sensors.
2013: Development of components for a 2nd generation silicon strip stave including service bus cables and hybrids. Commissioning of hybrid and module assembly tooling and fabrication and test of hybrids and modules using second generation components.
2014: Construction and test of a 2nd generation stavelet and full size silicon strip stave.
2015: Continued testing of 2nd generation system, analysis of results, and documentation.

WBS 6.2.3 DAQ and Control

Since the stave integrates a large number of sensor-readout units into a single structure, and uses a large multi-drop timing, trigger, and control system, it presents particular challenges to the DAQ and control framework. Aspects of this have already been addressed in precursor work including the development of a first generation high speed input/output (HSIO) system which can handle 48 parallel data streams and a prototype module controller ASIC. The aim of this part of the proposal is to extend and enhance the precursor work in order to operate and test the two generations of large stave systems planned.

Further work on the parallel HSIO DAQ system will focus on adding test and control functionality and adapting the system to the 2nd generation stave components. This will involve code development, both in firmware and software. While the core HSIO hardware (FPGA board) is quite powerful, the development will continue with the addition of a Reconfigurable Cluster Element (RCE) concept to allow more extensive local programming capabilities (for calibration and analysis) at the board level. A number of these new systems will be built and studied as tools for the 2nd generation stave electrical program.

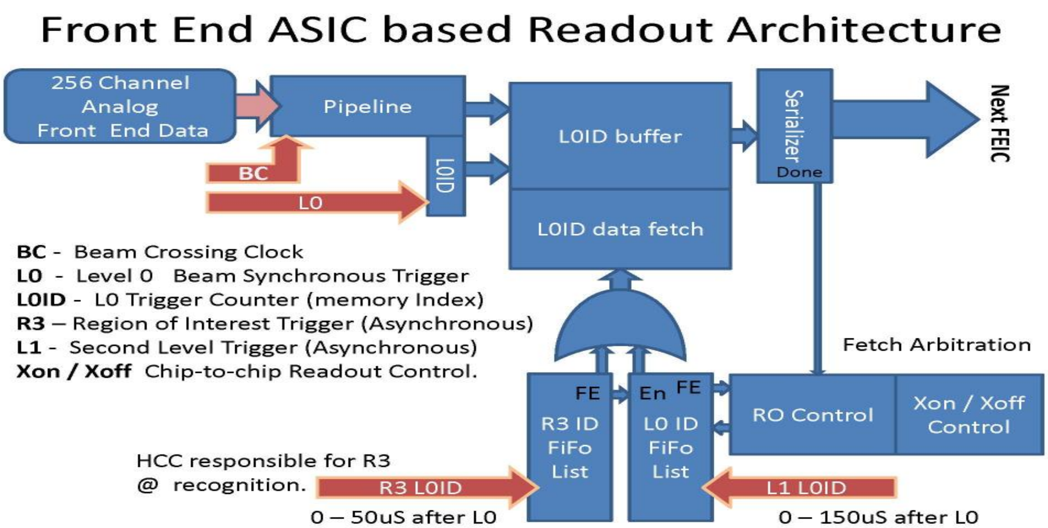


Figure 7: Readout architecture proposed for the silicon strip tracker front end ASIC. Triggers generated by the detector control data storage and the data transmission priority on the front end ASIC. Data are transferred from the 256 channel analog front end into the pipeline at each beam crossing.

Work on module control circuits and protocols will occur within a collaboration in which several of the present institutions are members and which includes a strong electronics group at CERN. This group is addressing the problem of developing a new generation of trigger regulated readout architecture for strip detector mounted front end electronics. An example of the front end architecture is shown in **Figure 7**. This group is designing a set of prototype ASICs consisting of a 256 channel silicon strip readout chip, called the ABC130 (primary responsibility CERN) and a Hybrid Controller Chip, HCC (primary responsibility USA) intended to interface between the end of the stave and ten ABC130 front chips on a hybrid. The high level Verilog description logic should be completed by Q3, 2011. This chip set will require a radiation tolerant memory under development at CERN that will need to be carefully characterized by the HCC team before use in the chip. The target submission date for the two chips is Q2 of 2012. These ASICs are expected to be very similar to what might be desired at a very high luminosity hadron collider in terms of power, noise, and readout. This will allow realistic electrical tests on modules and staves of EMI, power services, digital control and readout reliability to be performed at BNL and LBNL in 2013. Barring serious design flaws a second, full functionality, chip set would be submitted in a dedicated engineering fabrication early enough in 2013 to allow for sufficient tested chipsets in 2014 to support the needs of the 2nd generation stave and module prototyping program.

Short Statements of Work and Milestones: This is a SLAC, Penn, LBNL and UCSC activity.

2011: Continue development and test of HSIO firmware and software. Test current version of hardware and iterate on any features needed. Most results will pertain to stavelet applications. Design work on HSIO+RCE system. Design and simulation of HCC, completion of high level Verilog description.

2012: Testing and adaptations of HSIO hardware, firmware, and software to readout a full length stave, both sides. Fabrication a number of HSIO+RCE systems, and apply as a stavelet test stand. Submission of first version of HCC chip.

2013: Adaptation of HSIO and HSIO+RCE system to HCC and ABCn-130 nm chipset. Develop higher speed interface card. Testing with 2nd generation hybrids and modules. Testing of HCC chip, application to hybrids and modules.

2014: Testing of HSIO and HSIO+RCE with 2nd generation stavelets and full length staves.

2015: Continued testing, analysis and documentation.

WBS 6.2.4 Powering

Inner tracking detectors at future colliders will require higher segmentation and channel density due to increasing luminosities. The result is that much higher current will be required to power inner trackers. The power must be delivered over long cables (tens of meters or more) as the supplies must be located in an accessible region outside of the radiation area. To avoid unacceptable ohmic losses in the cables, one either has to increase the mass of copper delivering power or one must deliver power via higher voltage and lower current to the detector elements in the inner tracker. The first option may be prohibitive due to cable mass and/or cable volume as either the mass is unacceptable due to radiation length considerations or the space constraints do not permit such cable volume. Understanding and implementing the second option is the goal of this aspect of the R&D program.

Delivering high voltage/low current power to the staves requires local conversion to the lower voltage/higher current required by the front-end ASICS. Two topologies that may be suitable to the environment of inners trackers are serial powering and DC-DC conversion. These are illustrated in **Figure 8** and are compared there to traditional high current parallel powering. DC-DC conversion via buck regulators is being actively pursued in industry for reasons of power efficiency; some of these developments, customized for collider environments may prove viable for the stave concept. Serial powering is a less known approach that has the advantage of not requiring the development of high voltage ASICS that are radiation hard.

The R&D program will include the following:

- Developing ASICs for locally converting current to voltage on each serially powered hybrid.
- Developing ASICs for fault protection of a serially powered chain of hybrids should an open circuit develop. Developing fault protection concepts in the case of a short circuit in a DC-DC powered chain of hybrids.

- System level testing of complete stave prototypes fully instrumented with silicon detectors and readout electronics. The testing will involve comparative studies of DC-DC powered staves with serially powered ones.
- Studies of broader issues of grounding and shielding for both stave topologies. These include both local grounding and shielding issues and those associated with multiple staves.
- Design and prototyping of detector high voltage distribution to decrease cable count. The system will switch high voltage on each stave via radiation hard switches.
- Irradiation of components to assess radiation tolerance.

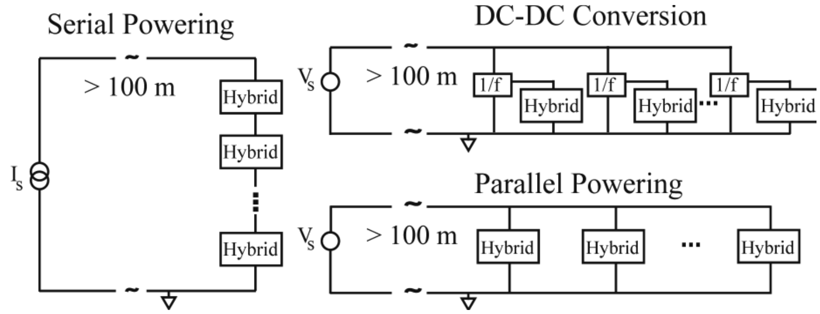


Figure 8: Schematics of three basic alternative powering schemes. In the most common Parallel scheme the supply lines must carry the sum of all currents needed by the hybrids. In a DC-DC scheme power is supplied at high voltage and low current. Clock driven converters at each hybrid supply the local required power. In a serial scheme the current of a single hybrid is supplied and each hybrid drops one local supply voltage step.

Short Statements of Work and Milestones: This is a BNL, Penn, UCSC, LBNL and SLAC activity.

2011: Build a serial powered stave segment ("stavelet"). Assemble test station to run stavelet. Begin system studies. Begin construction of a DC-DC powered stavelet. Submit an initial ASIC (SPP1) designed for serial power control and protection.

2012: Perform comparative system studies of serial versus DC-DC powered stavelets. Focus on grounding and shielding issues. Test SPP1 then submit SPP2 that contains additional necessary features. Prototype discrete component 600V HV distribution system.

2013: Select powering option based upon previous comparative studies. Begin design and construction of next generation stavelet featuring deep submicron readout ASICs. Test SPP2. Define specifications for a HV control ASIC.

2014: Test and characterize the next generation stave and stavelet. Fully understand grounding, filtering, and shielding issues. Design SPP3, a radiation hard version of SPP2.

2015: Finish research program. The program should have a chosen powering scheme with all grounding, shielding, and system issues understood. Document power, high voltage distribution, and serial power and control solutions.

WBS 6.3 Development of New Calorimeter Readout and Trigger Systems for Collider Detectors

Calorimeters are critical detectors in any HEP experiment, whether exploring the energy frontier at hadron or lepton colliders, or probing the intensity frontier at long baseline neutrino programs, rare event searches or flavor physics. They accomplish fundamental tasks from triggering to event selection to high precision measurements of electrons, photons, and jets, and missing transverse energy. Sophisticated technological advances in calorimeter technology have been made over the past decade through vigorous R&D programs. These advances aim to meet the stringent requirements needed for the physics that will be explored at future colliders. New materials for scintillation-based technologies, fine granularity calorimeters based on active semiconductor sensors, and dual readout detectors, are among the recent developments in calorimeter technology.

These advanced devices require advanced electronics readout circuitry. On the one hand, digital calorimeters are basically imaging devices due to their fine granularity. It can be estimated that a calorimeter using this technology in future colliders will have approximately 10^7 electronics channels. With this number of channels, the information from each one is limited to binary information or perhaps few significant bits. It is the collective information that is used for the extraction of the relevant information. On the other hand, traditional technologies such as scintillation based or noble liquid calorimeters have a much lower number of channels, typically 10^5-10^6 in coming collider experiments. In contrast to digital technology, information is obtained by processing the signal through low noise and high precision electronics. Through advanced processing techniques, data from these calorimeters will be able to drive topological pattern recognition at the same time that primitive quantities for both event reconstruction and event selection are obtained.

Our proposal will take the readout of "traditional" calorimeters, to an unprecedented level, matching advances in detector technology. We will seek to develop groundbreaking technology for real-time data processing of terabit-per-second expected data throughput and provide early stage event selection and event reconstruction. We propose to pursue a vigorous R&D program to develop specifically:

1. Low-power, high-performance on-detector front end readout electronics. Low power, low noise and large dynamic range electronics aiming at partial integration between signal conditioning, digitization and sparsification stages is the challenge faced for the readout of the next generation calorimeters for future colliders.
2. Large data-bandwidth optical modules. Future collider experiments calorimeters may require aggregate bandwidth up to 100Tbps, requiring 100Gbps or higher optical links. VCSEL arrays, serializers, laser drivers and trans-impedance amplifiers in small-form-factor packages for on detector installation, i.e. in high radiation environment, have yet to be developed to meet these requirements.
3. Tera-scale parallel processing units to extract real-time signal features and trigger primitives. High density, reconfigurable, parallel processing units, with throughput in excess of 1-2 Tbps per board, will allow centrally and globally reconstructed electromagnetic clusters and hadronic showers at the full calorimeter resolution. The early availability of this information will allow experiments to increase trigger efficiency and purity with small latency.

Our group has had a major role in the design, construction and operation of one the best calorimeter systems in operation today, the ATLAS liquid argon and tile calorimeters. Building on our experience we feel confident that the proposed R&D work will provide timely solutions to the issues listed above. The proposed program will certainly evolve into the basis of the ATLAS calorimeter readout upgrade as the first return on the investment made in this R&D program. The high luminosity Large Hadron Collider (HL-LHC) is a challenging environment for front end electronics and presents a formidable challenge for data processing. As the R&D work evolves, early results may already be incorporated into the incremental upgrade of ATLAS and also other LHC detectors, as our work will be general enough and results will be made available to all interested parties.

The merit of this proposal goes well beyond the HL-LHC. Development of the electronics, readout architecture and trigger interfaces will contribute to the electronics design for future collider experiments, large volume imaging devices in long baseline neutrino experiments and to other basic science fields where massive parallel processing is required within a very tight time budget. The sections below describe the R&D necessary to implement the proposed electronics developments. Detailed work plans and budget proposals can be found in Appendix D.

For reference in the main part of this section, a conceptual diagram of our model for calorimeter electronics is given in **Figure 9** with keys to the WBS organization.

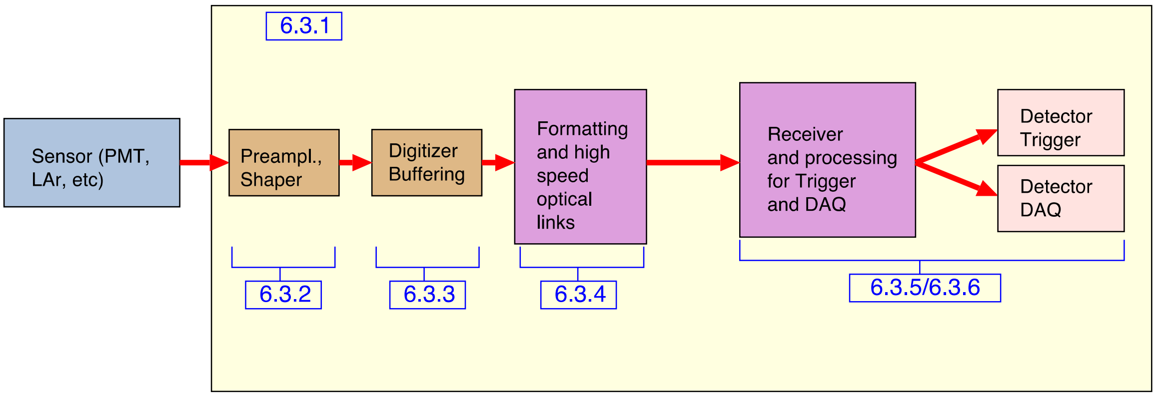


Figure 9: Conceptual model of calorimeter readout electronics.

WBS 6.3.1 Readout Architecture and System Integration

Collider detector electronics that is located on detector is usually inaccessible for months to years at a time. To ensure the extreme required reliability, design considerations should take into consideration the accelerator radiation environment, low power consumption and optimal distribution, and optimal integration with cooling. These conditions should not sacrifice the overall performance of end-to-end data throughput and dynamic range needed to retain all needed information for triggering and physics output. The following are the proposed system integration R&D needed for a new generation of calorimeter electronics.

Cooling – Removal of power dissipated by on detector electronics is a challenge due to the impossibility of using air cooling. This is a common problem faced by detectors that share the same restricted space. A common technique used in cases where the power density is relatively low, ~1-5 W/cm2, is to manage heat via liquid cooling. In the past it was possible to use heat exchangers to remove heat because it was relatively easy to pickup excess heat from all components. Newer integrated circuits transfer heat directly to the ground planes and to the printed circuit board ground planes. To address this problem we will seek an alternative method where heat will be conducted on the printed circuit board to liquid refrigerated points.

Power Distribution – It is the current thinking that power will be controlled locally through the use of point of load (POL) converters. We need a development program for POL converters that can operate in a radiation environment and not be sensitive to single event effects. The use of POL converters will significantly simplify power distribution to the crate, allowing for extreme flexibility for the board design.

Radiation Qualification and Testing - The higher luminosity of the future hadron colliders implies that all components will be subject to a much higher ionizing radiation and particle flux than in current colliders. Therefore, qualification to these new levels of radiation will be required. The bulk of the particles are neutrons and gammas up to E~800 MeV, with fluences up to 1-3×10^{12} n/cm^2, while charged particles rates are one order of magnitude smaller. During accelerator down times annealing can also take place. To simulate this situation we plan on designing test procedures making use of beam facilities such as LANSCE at Los Alamos, the gamma facility at BNL, the proton radiation facility at Massachusetts General Hospital, the Indiana University Cyclotron Facility, and the reactor at the UMass at Lowell. For a number of components we plan to pursue conversations with industry to obtain high reliability components at reasonable cost.

Short Statement of Work and Milestones: This WBS is an ANL, Arizona, BNL, Chicago, Columbia, MSU, U. Penn, and SMU activity.
2011-12: Conduct architecture study for advanced calorimeter readout. Publish the results
2012: Build prototype cooling system to be used with R&D results of other WBS areas and measure cooling efficiency. Identify one or more point-of-load (POL) power regulators and characterize their performance.
2013: Incorporate POL regulators into prototype boards from 6.3.2, 6.3.3, and 6.3.4. Measure performance of power distribution. Test with cooling system.
2014: Conduct initial radiation qualification tests of evolving designs from this R&D. Set up and perform tests at least three irradiation facilities to provide all types of radiation.
2015: Conduct final radiation testing, power distribution, and cooling tests. Document continuing architectural studies, identifying major options for future colliders.

WBS 6.3.2 Analog Signal Conditioning and Noise Optimization

Calorimeters in high energy physics have used at least two distinct readout schemes. Fast signals generated by optical devices such as photomultipliers are used in scintillator or crystal based calorimeters. Ionization calorimeters, such as liquid argon, produce a slower signal due to the current collection time in the electrodes. In the future, newer readout schemes that use silicon devices may become available. The first stage in any of the readout schemes is signal conditioning that requires amplification and signal shaping. Our group has substantial expertise in the two above mentioned technologies and we will profit from it to design, prototype and test signal conditioning application specific integrated circuits (ASICs) for both ionization and optical readout calorimeters. The large dynamic range (16 bits) and low noise requirements are the main challenges of the ASIC development.

Penn and and BNL have been collaborating since 2007 in the design of preamplifiers and shapers: A first prototype (LAPAS) was built in IBM SiGe 8WL in 2010 and tested successfully. In the next years we will take advantage of this strong collaboration to exploit improved application specific integrated circuit (ASIC) technologies that may allow for analog low power signal conditioning circuits and reduced number of gain scales, optimized for large input detector capacitance. Two technologies, bipolar and CMOS-only, have been explored for applications in high radiation levels, like the ones at the HL-LHC. Bipolar technology, due to its inherent linear performance over many orders of magnitude and high transconductance, is the most appealing. A CMOS-only solution, on the other end, may be needed because of the intrinsically higher resistance to displacement damage by neutrons.

Calorimeters using photodetectors such as photomultiplier tubes or silicon photomultipliers will need fast low noise charge sensitive amplifiers and digitization systems. We propose to develop, prototype and test two distinct solutions for high luminosity environments: (a) discrete components and separated amplifier, shaper and digitization ASICs, and (b) a single ASIC that incorporate all functions.

Signals from scintillator-based calorimeters must be conditioned and amplified within centimeters of the PMT source. For the discrete component option, challenges are presented by 40-80 MHz beam crossing signals, LVPS noise, and pileup of long signal undershoots at high luminosity. Additionally, calibration via charge injection and radioactive sources must be controlled at this initial gateway to the DAQ chain. The present ATLAS system has passive pulse shaping, two gain channels, and then amplified signals are sent by cable to ADCs on a Main Board. Advances in opamps, differential drivers, fast switches, and filter components present new low-noise possibilities for the signal path. We need to identify components meeting the noise and radiation tolerances with robust calibration and error correction.

The work on ASIC development is relevant to both this section and the next one (6.3.3). It is discussed in the next section.

Short Statement of Work and Milestones: This WBS is an ANL, BNL, Chicago, U. Penn activity.
2011: Preamp ASIC design and prototyping. First integration attempt with ADC.
2012: Prototype testing, decision on technology, and multichannel preamp design, prototyping.
2013: Multichannel preamp testing and package option studies.
2014: PCB layout for multi-channel preamp. Study noise and crosstalk.
2015: Finish Finalized high density PCB layout. Final report on ASIC and PCB development.

WBS 6.3.3 On Detector Digitization and Data Organization

The analog to digital converter (ADC) that is radiation tolerant is one of the main components in the proposed readout scheme. The main requirements for the ADC are: 12-bit dynamic range (or better), 40 MSPS digitization rate, low power consumption (< 300 mW/channel), low latency (< 8 clock cycles) and small footprint. These requirements, with the exception of radiation tolerance, are met by modern pipelined ADCs with built-in digital error correction. The development of a radiation-tolerant ADC is thus built on this architecture. IBM 8RF 130 nm CMOS technology was chosen for the implementation, benefitting from the common building blocks developed by CERN and other institutions, and moderate prototyping costs available through the CERN-MOSIS runs. A proposed architecture calls for three gains at the input, with analog or semi-digital gain selection incorporated in a 12-bit precision ADC channel. Each ADC chip is expected to digitize data from 4 calorimeter channels, i.e. take 12 inputs, and will thus fill a general need in HEP.

Functional blocks and a single stage pipeline converter prototype (Nevis10) have been designed and built in 2010. They are currently under test. A full ADC prototype will be fabricated late in FY2013. In addition to the “components” described above, the choice of number of bits to be resolved at each stage will be optimized. While the first stages can only resolve one bit to maintain accuracy, this need not be the case of the less significant bits, and latency can be reduced significantly. Potential options are: 111144 (four 1.5-bit stages each resolving one bit, and two 4.5 bit stages resolving 4 bits) with a 6-cycle latency, 1111224 with a 7-cycle latency, etc. If needed, a final ADC prototype would be produced in FY2014 and completely characterized by FY2015.

Digital Data Flow - A possible digital dataflow architecture would have 32 ADCs (4 calorimeter channels each), four MUX chips (32 each) and two 12-fiber optical transmitter arrays per front-end board (FEB). Assuming the error correction is done off-detector and each detector channel requires 18 bits of data - 2 gain + (12+4) ADC) - the links between the ADCs and the MUX chips could run at 720 Mbps (source–synchronous, bypassing the need for PLLs), and after the MUX 24 optical links running at 5 to 6 Gbps, depending on the chosen encoding scheme, would be sufficient to send the data. Other schemes are possible, trading link speed for number of links.
The MUX chip’s main technological challenge is in the high-speed serializer to the optical links. A serializer running at approximately 5 Gbps has been developed for IBM CMOS 8RF technology as part of the versatile link[12]. Higher speeds will require a different technology. For a link speed of 5 Gbps, the MUX chip could be developed in approximately two years, allowing for one prototyping cycle, tentatively scheduled for FY2014.

ASIC Development - A goal for high-rate, high-intensity colliding beam experiments is to be efficient in processing events. This requires high performance in the front-end electronics with regard to dead-time reduction, pile-up rejection, and event selection. In this type of environment, the front-end electronics must also be radiation tolerant to levels not seen in calorimeter electronics before. One example of a device that can perform dead-timeless digitization of charge signals is the QIE[13]. First designed in the 1990's, the device is a full-custom, self-contained integrated circuit for use in processing charge signals for high-rate experiments. The device integrates the current from the detector for an entire clock cycle, and then processes the signal using pipelining techniques with overlapping circuitry to achieve dead-timeless operation. The device is multi-ranging, and produces floating point data at 40-50 MHz using an on-board flash ADC. It has a least count resolution of order 10 fC, with a dynamic range of 16 bits. Because it can process charge signals within one clock signal, if the detector signal is fast, as is the case with silicon photomultipliers or fast phototubes, pile-up problems are greatly reduced compared with techniques that use long shaping times. The dead-timeless operation and reduced sensitivity to pile up make it an ideal device for use in high rate, high intensity experiments.

The latest fully-functional version of the QIE was developed for the calorimeters of CMS. We propose an effort to develop a new version of the QIE for future collider calorimeters. The new device would have the capability to measure the time of arrival of a signal in a given clock period with 1 ns resolution, which would be a new feature for the QIE. This requires a new set of circuitry to be designed into the chip, including an additional flash ADC. Many calorimeters require timing, so this development would be useful for a variety of applications. To achieve improved radiation tolerance, the new device would be designed in a SiGe process, which would also be a new aspect of the QIE design. The challenges are to understand the nature of the bipolar transistors in this process, in particular the matching characteristics and the collector-emitter saturation characteristics, both of which are particularly important in the QIE. In preliminary work, two prototype submissions have been made to the 0.35 micron SiGe process through MOSIS, mostly to test device performance and models. Through the proposed R&D we aim to produce a fully-functional, self contained integrated circuit that could be used with photo-detectors in high-rate experiments requiring large dynamic range and 1 ns timing resolution.

For the discrete component option, main boards receiving the conditioned PMT signals must digitize them, provide timing and controls, redundancy and error correction, serialization for fiber optic transmission to the counting room, and possibly trigger logic. A major challenge is to identify radiation tolerant PLDs that can provide the bandwidth necessary. With the recent advent of commercial fiber optic drivers in the several GHz range (and FPGAs that can keep up with that), there is the highly desirable possibility to send all PMT signals to the counting room thus allowing for flexibility in trigger logic.

Short Statement of Work and Milestones: This WBS is an ANL, BNL, Chicago, Columbia activity.
2011: Characterize the Nevis10 chip. Design of rad-tolerant reference voltage circuit and scalable OTA
2011: Integration test of LAPAS+Nevis10; development of the first full version of the new QIE, designated QIE10C.
2012: Complete design of digital part of ADC. Test the QIE10C at the bench chip to characterize the device. Perform radiation tests on the new QIE.
2013: ADC prototype chip submitted with the final changes to design of the QIE chip and fabricate of order ~50-100 chips.
2014: ADC prototype characterization and integration test with optical link. Instrument ~60 photo multiplier tubes with QIE readout. Design prototype front-end electronics based around the QIE capable of reading out the ATLAS TileCal as a realistic test system.
2015: Complete readout chain integration tests. Test of QIE and associated electronics in a test beam at CERN. Publish the results of these tests.

WBS 6.3.4 High Speed Optical Links and Trigger Input Solutions

High speed, low power, radiation tolerant optical links are vital components in many future experiments, including upgrades of present LHC experiments. The upgrade of the ATLAS LAr readout system, for example, calls for a data transmission bandwidth on the order of 100 Gbps per FEB. Some of the main developments needed for the next generation of calorimeters are high speed, radiation tolerant serializers and optical links that can meet this data bandwidth requirement.

To meet this challenge, we will work on multiple fronts. At component identification and development level, we are developing the Link-on-Chip (LOC) ASIC chip set (described below), and in parallel plan to irradiate TLK6002, a 6.5 Gbps serializer from TI, and several 10 Gbps laser diode driver (LDD) from different manufacturers. At the optical interface subsystem level, we benefit from the developments in the ATLAS/CMS common project, the Versatile Link, of which SMU is a member, to develop the radiation tolerant optical interface module (VTRx), identify radiation tolerant fiber and connectors, and develop system-level specifications for an optical link working in detector front-end environments. In this project we also gain the experience of using an industrial standard package with radiation tolerant components developed in our ASIC program to construct optical subassemblies with high reliability. For the receiving end, we are using serializer/deserializer embedded FPGAs and follow the development in industry to reduce the cost to the optical link system.

Using previous support from the US ATLAS R&D program and the DOE ADR program, we have successfully identified the 0.25 µm thin-film silicon-on-sapphire CMOS technology (the “GC” process from Peregrine Semiconductor Corp.) for high speed radiation tolerant ASIC development. Using this technology, we succeeded in prototyping two designs, the 5 Gbps (user data bandwidth) serializer LOCs1[14] and the 5 GHz LCPLL[15]. Based on these achievements, for the present R&D proposal we will investigate an array serializer design with each channel operating at 10 Gbps. Past simulation indicates that 8 – 9 Gbps may be reachable with tolerable power consumption. Peregrine has announced an improved “PC” process to be available for prototyping in June of 2011. Initial simulation with this new process indicates the circuit’s speed can improve 10-20% with about 50% area reduction. Collaborating with IBM, Peregrine also announced a new feature size of 180 nm. With the new PC process and the 180 nm technology, we expect to demonstrate 10 Gbps per fiber channel, our desired goal.

For the design work in the remainder of 2011 we will still use the GC process but prepare to migrate to the PC process once that process is stable. We plan to prototype using the PC design in 2012 and test the fabricated parts in 2012/13. We also plan to irradiate Components off the Shelf (COTS) (LDDs and serializers) in 2012/13 together with the ASIC prototype. System-level specifications and optical interface development will continue into 2013/14. The ASIC development, including packaging and system integration may need two iterations, is the work for 2013 to 2015. We plan to have an optical link system demonstrator ready in 2016.

A major challenge under harsh beam or radiation environments is data corruption from single event upsets. High density FPGAs, serializers, and fiberoptic tranceivers are particularly sensitive to this type of data corruption. R&D is necessary to qualify the new generation of high-speed, high-density devices and to devise a protocol of data transmission redundancy and error correction. Furthermore, multi-GHz bandwidths require that the serializer portions of large main boards be fabricated on high-speed RO4003B boards, which requires considerable PCB layout studies and qualification of impedance-match high capacity connectors for the inevitable mezzanine boards that will carry the high-bandwidth sections of the Main Board.

Short Statement of Work and Milestones: This WBS is a Chicago, SMU activity.
2011: 2-lane LOCs2 prototyping based on the GC process.
2012: 2- or 4-lane LOC serializer prototyping based on the PC process.
2013: LOC serializer final prototyping, with the PC process or 180 nm technology.
2014: Integration of the MUX and the serializer ASIC, packaging option study.
2015: ASIC QA and production readiness review.

WBS 6.3.5 Data Organization and Processing for Presentation to the TDAQ System

In the fully digital readout scheme that we are proposing, the digital data concentrators are one of the most critical elements in the readout chain. We propose to develop such a data concentrator to receive data at (for example) the LHC 40 MHz clock rate and to process the data stream to extract energy and time information without incurring dead time. They will also play the role of forming energy sums for triggering. The R&D for the digital data concentrators is generic and reflects the paradigm shift to all digital signal filtering and processing that is likely to be present in future experiments.

Past work done in collaboration between the University of Arizona and BNL has resulted in a possible architecture for the digital data concentrators that will require substantial additional R&D program to turn ideas and lower bandwidth models into a complete working prototype. MSU is doing extensive MC simulations, aiming to define the optimal data preprocessing and presentation for trigger processors. In the new architecture each receiver must process data at approximately 1.6 Tbps. The architecture is based around the ATCA, which is a telecommunications industry standard platform. We envision each digital data concentrator to consist of an ATCA carrier board holding four Advanced Mezzanine Cards (AMC's), each consisting of parallel high-speed (10 Gbps) optical inputs and high density Field Programmable Gate Arrays (FPGA's) for deserialization and digital signal processing. The proposed architecture can greatly mitigate the risk during the module production since the costly components of the concentrator will be spread among four AMC modules. This scheme also allows board design and development to take place at multiple institutions.

In FY11-FY13 we plan to build AMC format modules running at 10 Gbps. MSU will focus on definition of the interface between calorimeters and triggering and prototyping of a rear transition module for optical transmission. BNL will focus on AMC format modules using Xilinx FPGAs and an Avago 12-channel parallel optical transceiver. Arizona will focus on AMC format modules using Altera FPGAs and keep at the forefront of the telecommunication industry in terms of high speed and density optical links (the current preference is for Optical Engines from Reflex Photonics). In terms of firmware, Arizona will focus on the digital signal processing, BNL will focus on trigger algorithms and interface to the data acquisition system and MSU will focus on the data presentation to the trigger and rear transition module firmware and test benches to test this firmware. By writing firmware in a common language, and by using a common development framework, all groups will be able to share design and simulation of the needed firmware. A large number of architectural questions remain including designs with lower speed optical links and alternative digital signal processing algorithms to which all groups will contribute. By the end of FY13 we will converge on a final design for the AMC modules. In FY14 BNL will lead the design of the ATCA carrier board while Arizona and MSU will focus on the rear transition module needed to send data to L1 trigger and software needed to test this module. In FY15 we will produce a complete, full speed prototype digital data concentrators consisting of the ATCA carrier board, four AMC modules, and a interface to a data acquisition.

Short Statement of Work and Milestones: This WBS is an ANL, Arizona, BNL, MSU, SBU activity.

2011: First prototype designs for 10 Gbps AMC modules for digital data concentrator and processor (DDCP) complete
2012: Working prototypes of 10 Gbps AMC modules for DDCP exist
2013: Final AMC module prototype and associated firmware, including trigger tower building, complete
2014: Prototypes of the rear transition module to L1, and of the ATCA carrier board complete.
2015: Final DDCP prototype complete. Final slice tests complete.

WBS 6.3.6 Calorimeter Trigger Interface

The previous sections of this proposal have outlined the specification and development of the major blocks of an advanced calorimeter readout system. In this section, we focus on the R&D of innovative trigger schemes to maximize the use of continuously streaming data from all calorimeters used by an experiment, e.g. Electromagnetic and Hadronic. This part of the proposal requires integration that affects the functionality of all of the blocks, especially those developed through the execution of WBS 6.3.4 and 6.3.5. The main motivation is to implement a flexible trigger to improve on search capabilities for new physics signatures in a high rate environment. We are seeking to implement a calorimeter trigger architecture based on multiple levels of hardware-based processing triggers that could be called Level 0 and Level 1 in the typical collider detector trigger scheme. A significant focus of the R&D will be to determine the optimum division of the triggering function between early processing on the detector itself and what needs to be done off the detector. We envision trigger levels that might be separated as follows:

- A level 0 (L0) trigger with acceptance rates in the range 100kHz to 1MHz with a few microseconds latency budget. L0 will perform bunch crossing identification, global statistical pattern recognition for the identification of electromagnetic clusters through shape analysis, and sliding window jet identification based on cone or kt-based algorithms.
- A level 1 (L1) trigger with acceptance rates of ~10kHz to resulting from selection algorithms for complex objects, e.g. precision topological algorithms, pi0 rejection, better reconstruction of the electromagnetic cluster position at L1, with performance close to the full-offline reconstruction in a fixed time budget of 30 to 50us.

Specific tasks in this section include the following:

- Specification and development of a Trigger Primitive Builder subsystem which could already operate on the detector, integrated with the functions of WBS 6.3.3 and 6.3.4. We will investigate the tradeoff of such an on-detector solution compared with an off-detector solution making use of the full streaming data. The goals for the Trigger Primitive Builder subsystem are to reliably form and digitize groupings of calorimeter cells optimized for the recognition of electromagnetic or hadronic clusters. The challenge in its implementation is the choice between analog or digital systems without the introduction of extraneous noise.
- Specification and development of a Trigger Primitive Extractor/Readout Processing Boards off-detector subsystem. This subsystem will be based on fast FPGA devices that will permit the implementation of real-time algorithms. The goal for the R&D of this device will be the development of fast algorithms for the extraction of signals features, trigger primitives and other topological variables for the L0 and L1 trigger stages. These algorithms will have to be accurate but also fit the constraint on execution time set by a fixed latency budget.

We plan to implement part of the developments in WBS 6.3.5 within the ATLAS detector, since this part of the program is strongly dependent on real event topologies and their processing. The association of the authors of this proposal with the ATLAS detector will permit a test of the new ideas and implementations under realistic conditions. The knowledge obtained will help further stages of R&D for on-detector solutions that could be used in future experiments elsewhere.

Short Statement of Work and Milestones: This WBS is an ANL, Arizona, BNL, Chicago, Columbia, MSU, Pennsylvania, SBU, SMU activity. This WBS follows closely the progress of WBS 6.3.5. In addition we have the following milestones.

2011: Complete first design of Trigger Primitive Builder
2012: Build and test first complete prototype Trigger Primitive Builder
2013: Build a partition system of the ATLAS calorimeter and test if on mockup by the end of 1st quarter
2014: Install it on the ATLAS detector by the 2nd half of FY 2014.
2015: Commissioned during the 2015 data taking at ATLAS.

Appendix A. WBS Structure and Overall Budget Summary

WBS Structure for Proposal		
WBS	Name	Institutions
6	Generic Collider R&D	
6.1	Hybrid Pixel Development	
6.1.1	Integrated Circuit Design	LBNL
6.1.2	IC test and irradiation and support for irradiations at the LANSCE facility	LBNL, New Mexico
6.1.3	Sensors and assembly testing and irradiation	UCSC, New Mexico, SLAC
6.1.4	Flex cables, micro-twinax, high speed communication	LBNL, SLAC, UCSC, New Mexico
6.1.5	Development of data acquisition system	SLAC
6.2	Development of Novel Modular Tracking Structures	
6.2.1	Development of thermal-mechanical stave cores and cooling/thermal management	BNL, LBNL, SLAC, Yale
6.2.2	Electrical assembly and test of staves and components	LBNL, UCSC, Duke
6.2.3	Development of multi-channel parallel data acquisition tools, interface and control circuits for stave readout	SLAC, LBNL, Pennsylvania, UCSC
6.2.4	Development and test of alternative powering systems	BNL, LBNL, Pennsylvania, UCSC
6.3	Development of New Calorimeter Readout and Trigger Systems	
6.3.1	Readout architecture and system integration	ANL, Arizona, BNL, Chicago, Columbia, MSU, Pennsylvania, SBU, SMU
6.3.2	Analog signal conditioning and noise optimization	ANL, BNL, Chicago, Pennsylvania
6.3.3	On-detector digitization and data organization	ANL, BNL, Chicago, Columbia
6.3.4	High speed optical links and trigger input solutions	Chicago, SMU
6.3.5	Data organization and processing for presentation to the DAQ system	ANL, BNL, Arizona, MSU, SBU
6.3.6	Calorimeter Trigger Interface	ANL, Arizona, BNL, Chicago, MSU, Pennsylvania, SBU, SMU

Table A-1: WBS Structure of this proposal

Collider Detector Research and Development Program Proposal Budgets (AY$)

WBS	University	Univ PI	FY11	FY12	FY13	FY14	FY15	Total Request
	University Subcontracts							
6.1	New Mexico	S. Seidel	63,937	144,420	151,471	158,945	166,149	684,922
6.1	UCSC	A. Grillo	118,815	154,407	160,570	163,426	170,349	767,567
6.1	Pixel subtotal		182,752	298,827	312,041	322,371	336,498	1,452,489
6.2	Yale	P Tipton	20,500	172,000	177,000	179,000	183,000	731,500
6.2	UCSC	A. Grillo	57,383	105,232	108,389	111,640	114,989	497,633
6.2	Duke	M. Kruse	4,000	67,346	68,773	69,988	71,228	281,335
6.2	Penn	B. Williams	101,942	177,437	174,070	154,465	151,713	759,627
6.2	Stave subtotal		183,825	522,015	528,232	515,093	520,930	2,270,095
6.3	Arizona	K. Johns	59,136	116,079	112,095	78,075	117,765	483,148
6.3	Chicago	M. Oreglia	150,100	317,802	325,984	335,296	344,887	1,474,069
6.3	Columbia	G. Brooijmans	201,388	425,630	458,642	426,812	435,148	1,947,620
6.3	Penn	B. Williams	72,369	125,800	104,688	107,661	111,225	521,743
6.3	MSU	J. Huston	74,500	147,000	152,000	152,000	152,000	677,500
6.3	Stony Brook	J Hobbs	40,928	88,543	88,543	88,543	81,855	388,410
6.3	SMU	J. Ye	208,938	322,451	329,069	364,986	313,807	1,539,251
6.3	Calorimeter Elec.'s subtotal		807,358	1,543,304	1,571,020	1,553,372	1,556,687	7,031,741
	University subcontract subtotal	**-**	**1,173,935**	**2,364,147**	**2,411,293**	**2,390,836**	**2,414,115**	**10,754,325**

WBS	Laboratory	Lab PI	FY11	FY12	FY13	FY14	FY15	Total Request
	Laboratory Budgets							
6.1	LBNL	M. Garcia-Sciveres	21,672	162,341	414,558	810,523	560,517	1,969,611
6.1	SLAC	Su Dong	111,700	236,800	319,600	354,300	346,000	1,368,400
6.1	Pixel subtotal		133,372	399,141	734,158	1,164,823	906,517	3,338,011
6.2	BNL	D. Lynn	198,310	395,960	393,843	441,433	422,114	1,851,660
6.2	LBNL	C. Haber	78,198	437,876	402,557	447,460	355,683	1,721,774
6.2	SLAC	Su Dong	121,900	175,800	148,500	178,200	131,500	755,900
6.2	Stave subtotal		398,408	1,009,636	944,900	1,067,093	909,297	4,329,334
6.3	ANL	L. Price	239,222	414,123	487,832	796,101	412,056	2,349,334
6.3	BNL	H. Takai	286,359	709,778	738,830	746,887	734,696	3,216,551
6.3	Calorimeter Elec.'s subtotal		525,581	1,123,901	1,226,662	1,542,988	1,146,752	5,565,885
	Laboratory subtotal	**-**	**1,057,362**	**2,532,678**	**2,905,720**	**3,774,903**	**2,962,567**	**13,233,230**

WBS	All Institutions	Level 2 PI	FY11	FY12	FY13	FY14	FY15	Total Request
	Collider Detector R&D Program Proposal Budget Totals							
6.1	Pixel subtotal	M. Garcia-Sciveres	316,124	697,968	1,046,199	1,487,194	1,243,015	4,790,500
6.2	Stave subtotal	C. Haber	582,233	1,531,652	1,473,132	1,582,185	1,430,227	6,599,429
6.3	Calorimeter Elec.'s subtotal	L. Price/H. Takai	1,332,939	2,667,205	2,797,682	3,096,360	2,703,440	12,597,626
	Subcontract processing fee		46,957	94,566	96,452	95,633	96,565	430,173
	Coll Det R&D Program Proposal Totals		**2,278,254**	**4,991,390**	**5,413,465**	**6,261,373**	**5,473,246**	**24,417,728**

Table A-2: Proposal's Summary Budget by WBS

Collider Detector Research and Development Program Proposal Budgets (AY$)

Proposal Budget Totals by Institutions						
Institution	**FY11**	**FY12**	**FY13**	**FY14**	**FY15**	**Total Request**
University subcontracts processed by BNL						
Arizona	59,136	116,079	112,095	78,075	117,765	483,148
Chicago	150,100	317,802	325,984	335,296	344,887	1,474,069
Columbia	201,388	425,630	458,642	426,812	435,148	1,947,620
Duke	4,000	67,346	68,773	69,988	71,228	281,335
MSU	74,500	147,000	152,000	152,000	152,000	677,500
New Mexico	63,937	144,420	151,471	158,945	166,149	684,922
Penn	174,311	303,237	278,758	262,126	262,938	1,281,370
SBU	40,928	88,543	88,543	88,543	81,855	388,410
SMU	208,938	322,451	329,069	364,986	313,807	1,539,251
UCSC	176,198	259,639	268,959	275,066	285,338	1,265,200
Yale	20,500	172,000	177,000	179,000	183,000	731,500
Subcontracts sub-total	**1,173,935**	**2,364,147**	**2,411,293**	**2,390,836**	**2,414,115**	**10,754,325**
BNL Labor and MS+T	**484,670**	**1,105,738**	**1,132,673**	**1,188,319**	**1,156,811**	**5,068,211**
Subcontract processing fee	**46,957**	**94,566**	**96,452**	**95,633**	**96,565**	**430,173**
BNL Proposal Total (FWP no. 2011-BNL-PO121-Fund)	**1,705,562**	**3,564,450**	**3,640,418**	**3,674,789**	**3,667,490**	**16,252,709**
Other laboratories submitting FWPs						
ANL (FWP no. 50344)	239,222	414,123	487,832	796,101	412,056	2,349,334
LBNL (FWP no. PH11438)	99,870	600,217	817,115	1,257,983	916,200	3,691,385
SLAC (FWP no. 10099)	233,600	412,600	468,100	532,500	477,500	2,124,300
subtotal	**572,692**	**1,426,940**	**1,773,047**	**2,586,584**	**1,805,756**	**8,165,019**
Collider Detector R&D Program Proposal Total	**2,278,254**	**4,991,390**	**5,413,465**	**6,261,373**	**5,473,246**	**24,417,728**

Table A-3: Proposal's Summary Budget by Institution

Appendix B. Statements of Work and Budgets for Pixel Development (WBS 6.1)

Lawrence Berkeley National Laboratory: Statement of Work and Budgets

WBS 6.1.1.
The main area of LBNL involvement in this R&D topic is integrated circuit design and the necessary testing to understand the integrated circuit integration into a full system. LBNL has a long history of developing integrated circuits for HEP. In the case of pixels, LBNL was the lead institution in the development of both the FE-I3 chip presently running in the ATLAS detector, and the FE-I4 chip that is the present state of the art, not yet operating in any experiment. In both cases the work involved international collaborations. In the case of FE-I4, the initial exploratory R&D was done solely at LBNL, but then for the development of a full chip a collaboration of 12 IC designers was formed, only 2 of which are from the US (LBNL). Similarly, the US paid approximately 20% of the fabrication costs of the first run of FE-I4 wafers and of the various test chips along the way. We intend to follow this same model for this R&D proposal, which highly leverages the US investment. At the time of this writing we are about to submit a first exploratory pixel matrix in 65nm feature size technology (analog circuits only), in a test chip shared among 4 different project at LBNL. The next step, which would be enabled by this proposal, is to evolve the development to an international collaboration as was done for FE-I4. At the same time we have already had a small participation in 3D integrated circuit R&D, an alternative to 65nm. In this case we provided support to foreign collaborators porting parts of the FE-I4 to 3D technology (within the Fermilab 3D consortium), as well as providing the analog front end for a Fermilab 3D prototype chip (VICTR). We propose to continue to support 3D development, while playing the lead role in 65nm.

Budget Justification – The main expense is for IC designer time as shown in the budget sheet. The work will be part time in early stages, with near full-time involvement of two designers needed for the assembly of a full size chip, estimated for FY14. A 20% share of the cost of a full chip submission in 65nm is estimated in FY15.

WBS 6.1.2.
Radiation testing is a critical part of the design process because we are using commercial IC technologies that were not designed for and are not rated for radiation tolerance. Our proposal is based on continued use of the LANSCE facility at Los Alamos, which is one of the few places in the world where we can achieve the needed dose using relatively high energy particles (800 MeV protons).

Budget Justification - Most of this work will be carried out by students and physicists already on the base program. In this proposal we include support for an undergraduate of post baccalaureate student hired as the testing needs intensify in the later years. The budget additionally contains funds for test printed circuit boards, readout components, and travel to Los Alamos.

WBS 6.1.4.
The goal of this section is to understand the electrical system that chips must operate in, as well as the integration of electrical services into the mechanical structures (covered under 6.2.1). Both of these activities must be taken into consideration for the IC design work. At the same time the mechanical structures and electrical interconnects must provide for the IC operating requirements.

Budget Justification – This budget is dominated by printed circuit board and flexible cable layout manpower. Most of the testing work would be performed by physicists and students supported on the base program, along with visitors. For the past 10 years we have had on-going success in attracting visitors with foreign funding for hardware R&D work that we expect to continue. A stipend is required to supplement their home source funds due to the high cost of living in Berkeley.

LBNL Pixel Development Budget (AY$) for Collider Detector R&D Program Proposal

			FY2011		FY2012		FY2013		FY2014		FY2015		Total	
WBS	**Tasks & Resources**		**FTE**	**Cost**	**FTE**	**Cost**	**FTE**	**Cost**	**FTE**	**Cost**	**FTE**	**Cost**	**FTE**	**Cost**
6.1.1	Pixel IC Design													
	Technician 1												-	-
	Technician 2												-	-
	Engineers 1	Mekkaoui	0.05	11,352	0.21	45,847	0.38	82,629	0.83	202,909	0.21	52,099	1.68	394,836
	Engineers 2	Gnani			0.08	12,618	0.21	30,484	0.67	104,083	0.04	7,169	1.00	154,354
	Student/PostBac1												-	-
	Student/PostBac2												-	-
	Materials&supplies							45,000		5,000		195,000		245,000
	Visitor Stipend													-
	Travel							5,000		5,000		5,000		15,000
	Total Direct		0.05	11,352	0.29	58,465	0.59	163,113	1.50	316,992	0.25	259,268	2.68	809,190
	Indirect			10,320		53,497		114,240		283,186		94,640		555,883
	Total		0.05	21,672	0.29	111,962	0.59	277,353	1.50	600,178	0.25	353,908	2.68	1,365,073
6.1.2	Test and Irradiation													
	Technician 1												-	-
	Technician 2												-	-
	Engineers 1												-	-
	Engineers 2												-	-
	Student/PostBac1						0.50	29,865	1.00	62,868	1.00	66,379	2.50	159,112
	Student/PostBac2												-	-
	Materials&supplies					2,000		12,000		15,000		15,000		44,000
	Visitor Stipend													-
	Travel													-
	Total Direct		0.00	0	0.00	2,000	0.50	41,865	1.00	77,868	1.00	81,379	2.50	203,112
	Indirect			0		405		26,676		54,078		56,928		138,087
	Total		0.00	0	0.00	2,405	0.50	68,541	1.00	131,946	1.00	138,307	2.50	341,199
6.1.4	Flex Cables and High Speed													
	Technician 1	Bryan Holmes			0.08	10,316	0.17	20,843	0.17	21,873	0.17	22,942	0.59	75,974
	Technician 2												-	-
	Engineers 1												-	-
	Engineers 2												-	-
	Student/PostBac1												-	-
	Student/PostBac2												-	-
	Materials&supplies					10,000		10,000		10,000				30,000
	Visitor Stipend					10,000		10,000		15,000		15,000		50,000
	Travel													-
	Total Direct		0.00	0	0.08	30,316	0.17	40,843	0.17	46,873	0.17	37,942	0.59	155,974
	Indirect					17,658		27,821		31,526		30,360		107,365
	Total		0.00	0	0.08	47,974	0.17	68,664	0.17	78,399	0.17	68,302	0.59	263,339
	LBNL Total		**0.05**	**21,672**	**0.37**	**162,341**	**1.26**	**414,558**	**2.67**	**810,523**	**1.42**	**560,517**	**5.77**	**1,969,611**

Table B-1: LBNL Pixel Development Summary Budget

<u>The University of California at Santa Cruz</u>: Statement of Work and Budgets

WBS 6.1.3. UCSC will work on two projects within this WBS. The first is the exploration of a pixel biasing scheme capable to reduce the device susceptibility to catastrophic damage due to large signals and the second one is the development of slim edges for the very cost effective n-on-p type sensor technology.

UCSC physicists have developed considerable insight into the physics of processes occurring in the silicon sensor in cases of abnormally large charge deposition, e.g. in a beam loss scenario. Our expertise was developed through the investigation of several generations of strip sensors, as well as in the context of a working strip amplifier chip. We will apply our knowledge to develop a biasing protection scheme for n-on-p pixel technology. We anticipate several rounds of cost-effective prototyping due to joint submissions of n-on-p sensors together with other groups and the international RD50 sensor collaboration. The goal for work in 2011 is to evaluate susceptibility of available pixel amplifier ASICs to large injected charges and to submit prototype sensor structures with different biasing schemes, to be evaluated in 2012. We foresee a second submission in 2013 and a full-size sensor submission in 2014 with a new protection structure. The final evaluation of the new scheme will be in 2015.

We see significant promise of laser-based scribe-and-cleave technology, followed by a specialized post-processing to develop slim edges. The method targets making an inert sidewall, which allows a proper electric field gradient at the edge of the device. It can be applied to finished devices and could in principle be made very cost effective. We will work on evaluating the technology for n-on-p sensors and transferring it from a few prototype pad diodes to strip sensors and pixel devices. In 2011-2012 we will make p-type strip sensors with custom sidewalls and study charge collection at the edge of the device, dependence on radiation dose, long-term stability and other factors. In 2013-2014 we will transfer the technology to pixel devices and evaluate their performance in a beam test. In 2014-2015 we will investigate industrialization of the technology and conduct a second beam test.

Budget Justification – For this activity, we require 16.7% (2 months) FTE per year level of effort of our engineering physicist, highly experienced in sensor development and test, to develop the necessary tests, analyze the test data and develop modifications to the biasing scheme and edge tailoring to achieve the desired results. We also require 20.8% FTE per year of our experienced assembly and test technician to fabricate test jigs, assemble sensors with test jigs and help with test system diagnosis. We plan to employ a new junior technician at 25% FTE per year to carry out the testing. Purchases of fabricated sensor wafers will be shared with international collaborators in order to minimize cost ($20k/year). The actual custom wafer cutting or dicing operations will be carried out by an outside vendor with whom we have initiated trials ($10k/year). We anticipate another $10k/year required for miscellaneous test equipment and assembly and test jigs. The domestic travel ($2k/year) is to visit collaborators to review data and plans. The foreign travel ($6k in FY13 and FY15) is for beam tests at the CERN laboratory to fully evaluate the new sensor designs under quasi-operating conditions. The first year FY11 is assumed to be an effective half-year in length and a 3% escalation factor is applied to each subsequent year.

WBS 6.1.4. We will investigate the data transmission limits for point-to-point links on flexible cables in the 500-1000 Mbps range, relevant for sustained data rates from pixel detectors at future colliders. This includes a study of the change of the dielectric properties of the bulk material with radiation and its effects on the maximum attainable data rate. In 2011 the work will focus on finding the maximum transmission speed on available cables without using enhancing digital or analog techniques. In 2012 we will evaluate the effect of different encoding schemes and design and fabricate specialized cables. This will be followed in 2013 by an irradiation test at LANL and a second round of cable fabrication in 2014, with the final evaluation and conclusions in 2015.

Budget Justification – For this activity, we require 16.7% FTE (2 months) per year level of effort of our engineering physicist to develop the necessary tests and analyze the test data. He will also perform simulations of novel cable designs and materials. We also require 8.3% FTE per year of our experienced electronics technician to carry out the testing. We have included the purchase of a bit error rate tester ($44.4k) in the first fiscal year. This will allow testing at bandwidths from 155 Mbps to 8500 Mbps fully covering the expected range of the performance of the cable under study, whereas our present equipment can only test up to 320 Mbps. $5k is included in FY12 and FY14 to purchase custom designed low-mass cables to test new cable designs. We anticipate another $5k/year required for miscellaneous test equipment and test jigs. The domestic travel ($2k/year) is to visit collaborators to review data and plans. The first year FY11 is assumed to be an effective half-year in length and a 3% escalation factor is applied to each subsequent year.

UCSC Pixel Budgets (AY$) for Collider Detector Program Proposal

		FY11		FY12		FY13		FY14		FY15		Total	
WBS	Tasks & Resources	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested
6.1.3	**Sensor and assembly testing and irradiation**												
	Labor												
	V. Fadeyev (EPhys)	0.08	8,565	0.17	17,643	0.17	18,172	0.17	18,718	0.17	19,279	0.75	82,377
	G.F. Martinez-McKinney (Tech)	0.10	7,189	0.21	14,809	0.21	15,254	0.21	15,711	0.21	16,183	0.94	69,146
	Tech (TBD)	0.13	5,261	0.25	10,838	0.25	11,163	0.25	11,498	0.25	11,843	1.13	50,604
	Total Salary & Fringe		21,015		43,291		44,589		45,927		47,305	-	202,127
	Wafer purchase		10,000		20,600		21,218		21,855		22,510	-	96,183
	Custom Wafer Cutting Services		5,000		10,300		10,609		10,927		11,255	-	48,091
	Misc. M&S		5,000		10,300		10,609		10,927		11,255	-	48,091
	Total other indirect		20,000		41,200		42,436		43,709		45,020	-	192,365
	Travel (1 domestic trip/year) (2 foreign trip in FY13 & FY15 for beam test)		2,000		2,060		8,487		2,185		9,004	-	23,737
	Total Direct		43,015		86,551		95,513		91,822		101,329	-	418,229
	Base Subject to Indirect		43,015		86,551		95,513		91,822		101,329	-	418,229
	Indirect		11,184		22,503		24,833		23,874		26,346	-	108,739
	Total	0.31	54,199	0.63	109,054	0.63	120,346	0.63	115,695	0.63	127,675	2.81	526,968
6.1.4	**Flex cables, micro-twinax, high speed communication**												
	Labor												
	V. Fadeyev (EPhys)	0.08	8,565	0.17	17,643	0.17	18,172	0.17	18,718	0.17	19,279	0.75	82,377
	M. Wider (Tech)	0.04	2,981	0.08	6,141	0.08	6,325	0.08	6,515	0.08	6,711	0.38	28,674
	Total Salary & Fringe		11,546		23,784		24,498		25,233		25,990	-	111,051
	Equipment (Bit Error Rate Tester)		44,399		-		-		-		-	-	44,399
	Low mass cable fab		-		5,000		-		5,000		-	-	10,000
	M&S (Misc supplies for testing)		2,500		5,150		5,305		5,464		5,628	-	24,046
	Total M&S (not incl equipment)		2,500		10,150		5,305		10,464		5,628	-	34,046
	Travel (1 domestic trip/year)		2,000		2,060		2,122		2,185		2,251	-	10,618
	Total Direct		60,445		35,994		31,924		37,882		33,868	-	200,114
	Base Subject to Indirect		16,046		35,994		31,924		37,882		33,868	-	155,715
	Indirect		4,172		9,359		8,300		9,849		8,806	-	40,485
	Total	0.13	64,617	0.25	45,353	0.25	40,224	0.25	47,731	0.25	42,674	1.13	240,598
	UCSC Pixel Development Total	**0.44**	**118,815**	**0.88**	**154,407**	**0.88**	**160,570**	**0.88**	**163,426**	**0.88**	**170,349**	**3.94**	**767,567**

Table B-2: UCSC Pixel Development Summary Budget

The University of New Mexico: Statement of Work and Budgets

WBS 6.1.2. We will organize and staff two to four proton irradiations per year at Los Alamos National Laboratory on behalf of teams, including ourselves, responsible for sensor, module, mechanics, and electronics innovation. This effort includes developing the proposal to the laboratory for beam time, characterizing pre-irradiated sensors, fixturing and installing the stack (typically 40+ devices), carrying out in situ monitoring and measurement, and overseeing dosimetry.

In addition to the proton beam effort, we are developing a pion beam program at LANL for use by ourselves and HEP collaborators. This project involves coordination with LANSCE staff and includes organization of test runs with various magnet configurations as well as data collection and analysis of primary flux and purity.

Budget Justification - In FY11, we require 0.075 FTE of Research Engineer Martin Hoeferkamp for development and preparation of custom fixtures; 0.075 FTE of graduate student Rui Wang for run management; and 0.125 FTE of graduate student Jessica Metcalfe for sensor characterization and dosimetry. In FY12 and subsequently, the time fractions of Hoeferkamp, Metcalfe, and Wang are increased proportionally to cover activity over the full 12 months. Benefits are charged at a rate of 35.5% for staff in FY11 (incremented by 2.5% per year) and 1% for students (not incremented). Graduate students also receive a health insurance benefit and partial tuition. Travel to Los Alamos is included, as are supplies for custom fixtures.

WBS 6.1.3. With the goal of predicting silicon sensor lifetime in a variety of future collider environments, we will carry out a comprehensive study of depletion voltage (extracted from capacitance measurements) of planar silicon sensors as a function of fluence, time, and temperature, for p- and n-type diodes in Magnetic Czochralski and Float Zone processing. We have access to the materials through our membership in RD50.

With the goal of scaling the size of single crystal CVD diamond for use in future collider experiments, we will work with two companies to develop a reliable method to grow crystals to 2 cm^2. We will characterize the scCVD material to quantify its quality, using charge collection and current-voltage measurements; irradiate and test it for radiation hardness; and examine new geometries (for example, thinner contacts) and alternative structures (such as 3D) that should increase charge collection. We have access to the materials through our membership in RD42.

Budget Justification - In FY11, we require 0.075 FTE of Research Engineer Martin Hoeferkamp for implementation of a custom charge collection system; 0.075 FTE of graduate student Rui Wang for diamond sensor measurements; and 0.125 FTE of graduate student Jessica Metcalfe for silicon sensor measurements. In FY12 and subsequently, the time fractions of Hoeferkamp, Metcalfe, and Wang are increased proportionally to cover activity over the full 12 months. Benefits are discussed under WBS 6.1.2. Travel covers trips to domestic collaborators' institutes for use of specialized sensor processing equipment and to review data and plans. Materials and supplies includes disposable clean room supplies.

WBS 6.1.4. We will contribute PC board and cable design and testing to the efforts in WBS 6.1.2 and 6.1.3. Custom design is required for remote monitoring of devices under test at LANSCE, for integration of the diamond detectors into larger systems, and for realization of the pion beam.

Budget Justification - In FY11, we require 0.1 FTE of Research Engineer Martin Hoeferkamp for design. We require 0.1 FTE of graduate student Rui Wang to assist with system integration and operations. In FY12 and subsequently, the time fractions of Hoeferkamp and Wang are increased proportionally to cover activity over the full 12 months. Benefits are discussed under WBS 6.1.2. Travel to domestic flex manufacturers and to Los Alamos is required. Materials and supplies covers small tools and PCB components.

New Mexico Budget (AY$) for Collider Detector R&D Program Proposal

			FY2011		FY2012		FY2013		FY2014		FY2015		Total	
WBS	Tasks & Resources	Personnel	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested
6.1.2	Test and Irradiation (bare IC and facility operation)													
	Engineers 1	Martin Hoeferkamp	0.08	4,863	0.20	13,617	0.20	14,299	0.20	15,014	0.20	15,765	0.88	63,558
	Student 1	Rui Wang	0.08	1,500	0.40	8,400	0.40	8,817	0.40	9,259	0.40	9,720	1.68	37,696
	Student 2	Jessica Metcalfe	0.13	2,500	0.50	10,500	0.50	11,022	0.50	11,574	0.50	12,150	2.13	47,746
	Tuition			713		998		1,048		1,101		1,155		5,015
	Fringe Benefits			3,247		6,538		6,965		7,433		7,731		31,914
	Travel			4,000		6,000		6,150		6,304		6,461		28,915
	Materials and Supplies			2,000		2,100		2,205		2,315		2,431		11,051
	Total Direct			18,824		48,153		50,506		53,000		55,413		225,896
	Indirect			5,130		12,260		12,859		13,494		14,107		57,850
	Total			23,954		60,413		63,365		66,494		69,520		283,746
6.1.3	Sensors and Assemblies including testing and irradiation													
	Engineers 1	Martin Hoeferkamp	0.08	4,863	0.20	13,617	0.20	14,299	0.20	15,014	0.20	15,765	0.88	63,558
	Student 1	Rui Wang	0.08	1,500	0.40	8,400	0.40	8,817	0.40	9,259	0.40	9,720	1.68	37,696
	Student 2	Jessica Metcalfe	0.13	2,500	0.50	10,500	0.50	11,022	0.50	11,574	0.50	12,150	2.13	47,746
	Tuition			713		998		1,048		1,104		1,155		5,018
	Fringe Benefits			3,247		6,538		6,965		7,433		7,731		31,914
	Travel			4,000		6,000		6,150		6,304		6,461		28,915
	Materials and Supplies			2,000		2,100		2,205		2,315		2,431		11,051
	Total Direct			18,824		48,153		50,506		53,003		55,413		225,899
	Indirect			5,130		12,260		12,859		13,494		14,107		57,850
	Total			23,954		60,413		63,365		66,497		69,520		283,749
6.1.4	Flex cables, micro-twinax, high speed communication													
	Engineers 1	Martin Hoeferkamp	0.10	6,485	0.10	6,810	0.10	7,150	0.10	7,507	0.10	7,883	0.50	35,835
	Student 1	Rui Wang	0.10	2,000	0.20	4,200	0.20	4,410	0.20	4,630	0.20	4,860	0.90	20,100
	Tuition			356		499		524		550		578		2,507
	Fringe Benefits			1,623		3,269		3,482		3,716		3,866		15,956
	Travel			2,000		3,000		3,075		3,151		3,231		14,457
	Materials and Supplies			1,000		1,050		1,103		1,158		1,216		5,527
	Total Direct			13,464		18,828		19,744		20,712		21,634		94,382
	Indirect			2,565		4,766		4,997		5,242		5,475		23,045
	Total			16,029		23,594		24,741		25,954		27,109		117,427
	New Mexico Total		**0.75**	**63,937**	**2.50**	**144,420**	**2.50**	**151,471**	**2.50**	**158,945**	**2.50**	**166,149**	**10.75**	**684,922**

Table B-3: New Mexico Pixel Development Summary Budget

<u>SLAC</u>: Statement of Work and Budgets

WBS 6.1.3. SLAC provides extensive experience with 3-D pixel sensors, since of the initial developers of this type of sensor are at SLAC. These are particularly appealing for the inner-most pixel layers where radiation damage is most severe. In addition it provides convenient access to the Stanford Nanofabrication Facility (SNF), where new types of sensors can be fabricated in small numbers to test ideas. In addition, the return of the SLAC test beam in 2011 provides a crucial locally accessible facility for sensor and module beam tests. SLAC will take the main responsibility for test beam instrumentation at the SLAC test beam. Active participation from SLAC in various irradiation and test beam activities are expected throughout the proposal period, in particular some leading contributions from physicists in test beam operations at both SLAC and other sites (not charged to this proposal).

Budget justification:
2011: The main effort will be design and construction of SLAC test beam telescope using existing pixel modules, mechanical support and cooling for device under test.

2013-2015: SLAC will provide evaluation of the design and fabrication of R&D sensor wafers, particularly of the 3-D type. The travel during these years corresponds to one international test beam trip, one international workshop/conference and one domestic workshop/conference.

WBS 6.1.4. SLAC's experience in high speed electrical data transmission for pixel detectors is particularly relevant for this proposal. Custom made radiation hard micro-coax/twin-ax cables R&D at SLAC with multi-Gb/s rate capability provides important alternative to optical data transmission in inaccessible high radiation area. This effort will extend into integration with high speed transmission devices such as GBT and design studies for end of stave regions. Together with the DAQ responsibility, it is natural for SLAC to contribute in a major way in the overall electrical integration of the pixel stave prototype.

Budget justification:
2011: Constructing an initial prototype test system to include the GBT ASIC with custom twin-ax for transmission tests and compare with other drivers.
2012: Design and fabrication of a first prototype of end of stave card with both data transmission and powering components. Initial exploration of multi-channel electrical integration.
2013-2015: Fabrication of re-optimized twin-ax design. Fabricating second generation prototype of end of stave card and extending the electrical integration towards full pixel stave prototype for data transmission and power distribution. Also exploring twin-ax designs for higher electrical data transmission rates at 10Gb/s or higher.
The travel budget each year corresponds to one international workshop/conference for two people and one domestic workshop/conference for one person.

WBS 6.1.5. The readout needs from single chip tests, to full stave level multi-channel systems and test beams can all leverage the high bandwidth generic DAQ R&D originated at SLAC with the Reconfigurable Cluster Element (RCE) concept on ATCA platform, including the extensive associated software utilities. Only moderate additional efforts for interface design and fabrication, and test software specific to this proposal to serve all test needs.

Budget justification:
2011: Establishing first readout setup for the SLAC test beam using mostly existing RCE prototypes and only minimal additional dedicated readout infrastructure components.
2012: Delivering the 2^{nd} generation DAQ hardware with HSIO+RCE merged board as the driver for the individual test stands at 3-4 collaborating institutions. In addition, a stave-level test setup for multiple RCE DAQ readout will be assembled at SLAC. Migration of core software to new RCE hardware and improvement in performance for multi-channel calibration/DAQ.
2013: Fabrication of multi-Gb/s interface boards for stave level tests and continue software effort for multi-channel calibration/DAQ.
2014: Full stave readout production hardware for at least two sites and possible upgrade of mezzanine cards for test stands.
2015: Full stave readout and calibration tests and possibly test beam. Tests will be performed with on very high data input rate interfaces.
There will be continued software support at core and application level for test stands. The travel budget is intended for two people travelling to one international workshop/conference each.

SLAC Pixel Development Budgets (AY$) for Collider Detector R&D Program Proposal

		FY2011		FY2012		FY2013		FY2014		FY2015		Total	
WBS	Tasks & Resources	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested
6.1.3	**Sensors and Assemblies including testing and irradiation**												
	Chris Kenney (eng phys)	-	-	-	-	0.05	9,500	0.05	9,800	0.05	10,100	0.15	29,400
	Jasmine Hasi (eng phys)	-	-	-	-	0.20	37,900	0.20	39,100	0.20	40,300	0.60	117,300
	Total salary + fringes		-		-		47,400		48,800		50,300	-	146,500
	SLAC test beam mech setup		-		-		-		-		-	-	-
	R&D wafer fabrication		-		-		15,000		15,000		15,000	-	45,000
	Misc. M&S		-		-		4,000		4,000		4,000	-	12,000
	Travel		-		-		7,000		7,000		7,000	-	21,000
	Total Direct		-		-		73,400		74,800		76,300	-	224,500
	Indirect		-		-		37,300		38,300		39,200	-	114,800
	Total		-		-	0.25	110,700	0.25	113,100	0.25	115,600	0.75	339,400
6.1.4	**Flex cables, micro-twinax, high speed communication**												
	Martin Kocian (eng phys)	0.10	19,000	0.10	19,000	0.15	28,500	0.25	48,800	0.25	50,300	0.85	165,600
	David Nelson (elec eng)	0.05	11,500	0.10	22,900	0.10	22,900	0.10	23,600	0.10	24,300	0.45	105,200
	Pham Tung (elec tech)	-	-	0.05	6,000	0.05	6,000	0.05	6,100	0.05	6,300	0.20	24,400
	Total salary + fringes	-	30,400	-	47,900	-	57,300	-	78,600	-	81,000	-	295,200
	Materials&supplies	-	10,000	-	10,000	-	10,000	-	10,000	-	10,000	-	50,000
	Travel	-	6,500	-	6,500	-	6,500	-	6,500	-	6,500	-	32,500
	Total Direct	-	46,900	-	64,400	-	73,800	-	95,100	-	97,500	-	377,700
	Indirect	-	24,800	-	36,500	-	42,800	-	57,100	-	58,700	-	219,900
	Total	0.15	71,700	0.25	100,800	0.30	116,700	0.40	152,200	0.40	156,200	1.50	597,600
6.1.5	**DAQ for above activities**												
	Martin Kocian (eng phys)	0.05	9,500	0.10	19,000	0.10	19,000	0.05	9,800	0.05	10,100	0.35	67,400
	Matthias Wittgen (comp prog)	0.05	8,600	0.10	17,200	0.10	17,200	0.10	17,700	0.10	18,200	0.45	78,900
	Pham Tung (elec tech)	-	-	0.05	6,000	0.05	6,000	0.05	6,100	0.05	6,300	0.20	24,400
	Total salary + fringes	-	18,100	-	42,100	-	42,100	-	33,600	-	34,600	-	170,500
	Test stand hardware prototypes	-	6,000	-	50,000	-	10,000	-	20,000	-	5,000	-	91,000
	Misc. M&S	-	3,000	-	3,000	-	3,000	-	3,000	-	3,000	-	15,000
	Travel	-	-	-	5,000	-	5,000	-	5,000	-	5,000	-	20,000
	Total Direct	-	27,100	-	100,100	-	60,100	-	61,600	-	47,600	-	296,500
	Indirect	-	13,000	-	35,900	-	32,100	-	27,300	-	26,600	-	134,900
	Total	0.10	40,100	0.25	136,000	0.25	92,200	0.20	88,900	0.20	74,200	1.00	431,400
	Total SLAC Pixel Development	**0.25**	**111,700**	**0.50**	**236,800**	**0.80**	**319,600**	**0.85**	**354,300**	**0.85**	**346,000**	**3.25**	**1,368,400**

Table B-4: SLAC Pixel Development Summary Budget

Appendix C. Statements of Work and Budgets for Modular Tracking Structures (WBS 6.2)

Brookhaven National Laboratory: Statement of Work and Budgets

WBS 6.2.1. BNL will be collaborating with Yale and LBNL to develop extremely low mass carbon composite stave cores. The research program will be broad and encompass material studies, large multi-stave support, quality assurance techniques, and manufacturability. Our anticipated annual research program follows.
2011: We will focus on studying an existing large stave core prototype. This will involve thermal and mechanical characterization. We will model with thermal and mechanical simulation software and attempt to get agreement between simulation and data in order to validate the simulation software for future studies. We will also work on prototyping a stave support bracket scheme. Initially these brackets will mount in a custom frame for stave storage but they will also demonstrate the concept for support for actual implementation on larger support structures.
2012: We will fabricate a second large stave using co-cured facings supplied by LBNL. Foam-tube assemblies will be supplied by Yale. Potentially we may attempt to use lower mass titanium cooling pipes depending if reliable connection techniques can be established at this juncture. We will fully characterize this stave prototype and compare results with the non co-cured stave core. Additionally will work on resonant frequency measurements of the both stave cores and compare with simulation. We will work with Yale to understand the critical foam-pipe interface under thermal stress.
2013: BNL with Yale and LBNL will work on a more ambitious stave core with the goal of aggressively reducing mass. Our fully developed simulations will be a primary tool for exploring various options. It is foreseen that a fully instrumented stave with deep sub-micron ASICS will be built; either this aggressive stave core will be used for the stave, or the more conservative design developed in 2011-2012 will be used and built by BNL/Yale. BNL and Yale will also prototype peek-carbon fiber support brackets.
2014: We will have built a final stave core and have it completely characterized. BNL and Yale will continue to develop QA techniques such as ultrasonic imaging (with LBNL) and convective heating. BNL will develop and model multi-stave support concept including simulation. We will initiate studies of large scale assembly of staves.
2015: We will finalize our work on stave cores and document. We will finish the multi-stave support mechanical study and document. We will finish our work on QA techniques and document. We will finish our large scale assembly of staves study and document.

Budget Justification - BNL's research program will require a large amount of prototyping and fabrication. The fabrication is primarily in-house, with a few of the main items expected to be prototyped in industry. Material costs are therefore primarily carbon composite materials, jigs, aluminum plates, etc, that are needed for prototype fabrication. The research program also requires a great deal of design and simulation work and this is reflected in the request for a 0.3 FTE mechanical engineer. In addition to in-house fabrication, we will require extensive test and measurement of prototypes, both thermally and mechanically. This is reflected in the request for typically a 0.8 FTE mechanical technician.
2011: Engineer will work on developing thermal and mechanical model of large stave we recently build. He also will work on the bracket support design. Technician will work on brackets and frame for the stave and perform extensive test and measurements on the stave. Consumables for frames and test jigs will be required.
2012: Engineer will further develop simulation stave model to include silicon and electronics. He will use these models further to do vibrational analysis including effects of the support mechanism. Technician will build the co-cured stave and begin tests and measurements. In addition to material for stave construction, we anticipate ordering (along with pixels to lower cost) low density carbon fiber pre-preg for later second generation stave core.

2013: Engineer will use the validated software simulation packages to explore second generation designs to lower stave mass. Technician will work on material characterization, making test coupons for QA techniques, and bracket characterization. In addition to materials for test coupons, jigs for bracket characterization, and parts needed for QA test stands, we anticipate placing an industrial order for prototype support brackets.
2014: Engineer will work on multi-stave support simulation. He will participate in studies of large scale assembly of staves. Technician will build one or two second generation low mass stave-cores. Material will be need to make a mini multi-stave support prototype.
2015: Engineer will document results of stave development program. Technician will finish characterization of second generation stave cores.

WBS 6.2.4. BNL will collaborate with Duke, LBNL, Penn, and UCSC on various aspects of local power distribution on staves and power delivery to staves. This will include serial power vs. DC-DC comparisons, grounding and shielding studies, EMI minimization, as well as high voltage distribution on the stave. BNL will establish a testbed utilizing a serial powered stavelet and modules to test various concepts; these will be a resource for collaborators from Duke and Penn to test various power and shielding schemes as well as protection ASICs.
2011: We will produce ~ 60 Power Protection Circuits for serial power stavelets to fully test our initial protection concepts. We will set up a testbed for power studies featuring a fully instrumented stavelet and a HSIO-DAQ. We will start testing grounding and shielding issues with the testbed stavelet. The SPC serial power ASIC from Penn will be fabricated. We will provide complementary testing of the circuit. This circuit provides shunt regulator control. We will prototype a radiation hard GaN switch based 200V high voltage distribution system for silicon detectors on staves.
2012: Along with Penn, we will test various filters for a serial powered stavelet. Grounding and shielding studies will continue. We will do testing on the SPP1. This circuit incorporates shunt regulation control and elements of serial power protection. Potentially, in collaboration with LBNL, we will test a DC-DC stavelet and do comparative studies with a serial powered stavelet. We will prototype a radiation hard GaN switch based 600V high voltage distribution system switches for silicon detectors on staves.
2013: We will explore alternative technologies to GaN based HV distribution if necessary. We will along with Penn/UCSC define specifications for an ASIC to control the HV distribution. We will . collaborate with Penn to test the SPP2.
2014: We will collaborate with Penn to define the functionality and topology of a radiation hard serial power protection and control ASIC (SPP3). Grounding and shielding designs will be implemented on a next generation stavelet and tested.
2015: We will, along with Penn, test a high voltage distribution system employing the control ASIC. We will collaborate with Penn to test SPP3, a radiation hard serial power protection and control ASIC. We will collaborate to make the final analysis and documentation of both ASICs.

LAB 11-438

BROOKHAVEN NATIONAL LABORATORY

PHYSICS DEPARTMENT

COST PLAN PROPOSAL

WBS 6.2.1

Description	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total 5 years
COST PLAN	**136,820.65**	**281,247.32**	**274,972.61**	**284,190.89**	**293,779.26**	**1,271,010.73**
050 - Base Salary	71,790.04	143,580.07	149,036.12	154,699.49	160,578.07	679,683.79
SALARY	**71,790.04**	**143,580.07**	**149,036.12**	**154,699.49**	**160,578.07**	**679,683.79**
280 - Foreign Travel	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	10,000.00
290 - Domestic Travel	0.00	2,000.00	2,000.00	2,000.00	2,000.00	8,000.00
300 - PO Purchases	11,000.00	27,000.00	17,000.00	17,000.00	17,000.00	89,000.00
MSTC-LV	**13,000.00**	**31,000.00**	**21,000.00**	**21,000.00**	**21,000.00**	**107,000.00**
251 - Electric - Distributed	1,378.37	2,756.74	2,861.49	2,970.23	3,083.10	13,049.93
OTH-EXEMPT	**1,378.37**	**2,756.74**	**2,861.49**	**2,970.23**	**3,083.10**	**13,049.93**
700 - Organizational Burden	9,045.54	18,091.09	18,778.55	19,492.14	20,232.84	85,640.16
DEPT-CHRGS	**9,045.54**	**18,091.09**	**18,778.55**	**19,492.14**	**20,232.84**	**85,640.16**
705 - LDRD Burden	4,730.78	9,726.56	9,503.73	9,822.58	10,153.55	43,937.20
710 - G&A Burden	7,806.14	16,049.54	15,681.91	16,208.03	16,754.15	72,499.77
720 - Common Support	25,924.38	53,300.96	52,079.86	53,827.13	55,640.79	240,773.12
725 - IGPP Burden	2,365.39	4,882.36	4,770.95	4,911.29	5,076.77	22,006.76
745 - Procurement	780.00	1,860.00	1,260.00	1,260.00	1,260.00	6,420.00
LABWIDE-OH	**41,606.69**	**85,819.42**	**83,296.45**	**86,029.03**	**88,885.26**	**385,636.85**
050 - PROF4 - 14676 - KIERSTEAD ,JAMES	0.03	0.05	0.05	0.05	0.05	0.23
050 - PROF4 - 21149 - GORDEEV ,ANATOLI	0.15	0.30	0.30	0.30	0.30	1.35
050 - TECH2 - 20660 - BURNS ,RUSSELL	0.20	0.40	0.40	0.40	0.40	1.80
050 - TECH3 - 20051 - SEXTON ,KENNETH	0.20	0.40	0.40	0.40	0.40	1.80
TOTAL PERSONNEL	**0.58**	**1.15**	**1.15**	**1.15**	**1.15**	**5.18**

LAB 11-438

BROOKHAVEN NATIONAL LABORATORY

PHYSICS DEPARTMENT

COST PLAN PROPOSAL

WBS 6.2.4

Description	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total 5 years
COST PLAN	**61,489.84**	**114,712.78**	**118,870.05**	**157,241.74**	**128,335.16**	**580,649.57**
050 - Base Salary	33,512.72	67,025.43	69,572.40	72,216.15	74,960.37	317,287.07
SALARY	**33,512.72**	**67,025.43**	**69,572.40**	**72,216.15**	**74,960.37**	**317,287.07**
300 - PO Purchases	4,500.00	3,500.00	3,500.00	26,000.00	4,000.00	41,500.00
MSTC-LV	**4,500.00**	**3,500.00**	**3,500.00**	**26,000.00**	**4,000.00**	**41,500.00**
251 - Electric - Distributed	643.44	1,286.89	1,335.79	1,386.55	1,439.24	6,091.91
OTH-EXEMPT	**643.44**	**1,286.89**	**1,335.79**	**1,386.55**	**1,439.24**	**6,091.91**
700 - Organizational Burden	4,222.60	8,445.20	8,766.12	9,099.23	9,445.01	39,978.16
DEPT-CHRGS	**4,222.60**	**8,445.20**	**8,766.12**	**9,099.23**	**9,445.01**	**39,978.16**
705 - LDRD Burden	2,125.27	3,959.03	4,102.43	5,443.77	4,432.27	20,062.77
710 - G&A Burden	3,506.86	6,532.74	6,769.35	8,982.58	7,313.62	33,105.15
720 - Common Support	11,646.32	21,695.23	22,481.02	29,831.57	24,288.53	109,942.67
725 - IGPP Burden	1,062.63	2,058.26	2,132.95	2,721.88	2,216.13	10,191.85
745 - Procurement	270.00	210.00	210.00	1,560.00	240.00	2,490.00
LABWIDE-OH	**18,611.08**	**34,455.26**	**35,695.75**	**48,539.80**	**38,490.55**	**175,792.44**
050 - PROF4 - 14676 - KIERSTEAD ,JAMES	0.03	0.05	0.05	0.05	0.05	0.23
050 - TECH3 - 19929 - KUCZEWSKI ,PHILLIP	0.25	0.50	0.50	0.50	0.50	2.25
TOTAL PERSONNEL	**0.28**	**0.55**	**0.55**	**0.55**	**0.55**	**2.48**

Table C-1: BNL Stave Development Summary Budget

Lawrence Berkeley National Laboratory: Statement of Work and Budgets

Lawrence Berkeley National Laboratory will work in the area of pixel stave mechanics and strip stave electrical integration and test, DAQ development, and alternative powering.

WBS 6.2.1. For pixel staves, the LBNL effort will focus on the development and test of thermal foams and associated materials (adhesives). The proposed development path over the next 4-5 years has a number of essential components. One, is to continue the development and characterization of the foam material in collaboration with industry. Two is the fabrication and test (thermal performance, deflection, stability, etc) of prototypes of different structures that match the needs for different regions of future trackers. Three, reliability testing (thermal cycling, irradiation and handling) is critical for any design. Four, detailed modeling of thermal and mechanical performance will be undertaken. Five, is to continue efforts to reduce the radiation length of the structures. This will require working with the foam manufacturer to achieve the same thermal conductivity and strength but at lower density and working with carbon fiber vendors to produce low areal-weight fiber prepreg with high in-plane (and adequate out-of-plane) thermal conductivity. We also propose development of adhesives (to attach a cooling pipe to foam and foam to carbon fiber) with improved thermal conductivity, replacing boron-nitride fillers with carbon nanotube fillers.

For strip staves, effort will focus on several particular issues. Co-cure experiments have been on-going at LBNL. These will continue into 2012-2013 with the intention of completing basic process development and transferring the technology to partner institutions including BNL, Yale, and international collaborators. The other area of focus will be basic material studies, partially in concert with the pixel stave work. As these materials become available, fundamental material properties will be measured as input to simulation and other calculations. LBNL will provide the institutional liaison between pixel and strip mechanical efforts.

Budget Justification - This work requires 50% FTE per year level of effort of mechanical technicians in our composites shop to process samples and fabricate components for the new materials studies. We will also use a mechanical engineer, initially at the 8% level but escalating up to 25% in order to perform simulations and oversee analytical work on these materials. We have and would continue to engage the services of an outside consultant in order to work with the new materials which the consultant's firm has developed. The consultant also performs simulations and other calculations needed for these studies. In 2012 and 2014 we would make large minimum order procurements of carbon materials needed for the program. The baseline supplies cost of about $10K/year covers other materials and fabrications needed to maintain the program. LBNL indirect rates are determined institutionally.

Much of the mechanical work on strip staves takes place at other institutions. Because of the larger pixel effort at LBNL, we can fill a unique role to maintain the connection between strip and pixel work particularly concerning the use of the new high performance thermal foams. We have also led the work on bus cable to carbon facing co-cure and would continue that aspect as well. For these efforts we require 8% of a mechanical technician in the composites facility and $10K-$15K of procurements/year.

WBS 6.2.2. In 2011, 1st generation strip modules will be assembled and tested. A bus cable will be designed with a shield-less option in order to test low mass alternatives. Assembly will begin on a stavelet utilizing the strip modules. In 2012 effort will continue in the assembly and test of a full length 1st generation stave. In 2013 design and fabrication will begin on 2nd generation components including hybrids, modules, and service bus cables. In 2014 the 2nd generation full length stave will be fabricated and tested. This effort will extend into 2015 when analyses and documentation will be completed as well.

Budget Justification - In order to carry out the staves electrical work we require 8-13% of a printed circuit board designer and a machinist. These individuals produce the various test boards, interfaces, and fixtures required to carry out this work. Many of these parts are also distributed or shared with other institutions. The materials cost covers the fabrication of printed circuits and the purchase of needed components and supplies. The amounts are based upon previous year's costs. We also include a one-time cost of $100K to cover a large procurement of sensors which is required for the 2nd generation stave fabrication. LBNL indirect rates are determined institutionally.

WBS 6.2.3. In 2011 work will continue on HSIO software and firmware. Code development will include temperature readout from hybrids and modules and digital stave tests for data transmission. Tests will occur of the BCC chip, a precursor to the HCC. Work will also continue on a 1st generation end-of-stave (EOS) card. In 2012 tests will continue on HSIO with additional code development. In particular, HSIO will be fully applied to a complete length stave. In 2013, HSIO will be adapted or evolve into a system which can address the HCC and ABC130 chipset. HSIO will also be used to address slow control and monitoring functions. Digital data transmission tests of HCC systems will occur. New versions of EOS and interface boards will be developed. In 2014 HSIO will be applied to a full length 2nd generation stave, new versions of EOS and interface boards will be fabricated. In 2015, tests will be completed and documented.

Budget Justification - The costs here cover basic materials and supplies purchases such as components and printed circuit fabrication. Design effort comes from other collaborators. We support one-half of a post-doc or other term appointed physicist to work on the DAQ development and testing. Other Labor is from students or other physicists not on this budget.

WBS 6.2.4. In 2011 tests will continue of serial powering on stavelet and stave prototypes. A test of DC-DC conversion on a stavelet will occur. A paper analysis will be completed comparing serial power and DC-DC at the full system level, including material estimates. In 2012, a full length 1st generation stave will be completed with one of serial or DC-DC powering. Tests will be made of powering control, monitor, and bypassing. In 2013, working with BNL, UCSC, and Penn, SPP will be tested on 2nd generation modules. In 2014, this will be applied to the full length 2nd generation stave.

Budget Justification - Costs are only for materials and supplies such as components and printed circuits. Most of the hardware comes from collaborating institutions.

LBNL Stave Development Budgets (AY$) for Collider Detector R&D Program Proposal

			FY2011		FY2012		FY2013		FY2014		FY2015		5-Year Total	
WBS	Tasks & Resources	Personnel	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested
6.2.1	**Stave Mechanical**													
6.2.1.1	**Pixels Mechanical**													
	Technician 1	Tom Johnson	0.17	17,152	0.50	53,441	0.50	55,264	0.50	58,021	0.50	60,853	2.17	244,731
	Technician 2												-	-
	Engineers 1	Silber/Anderssen/Others			0.08	8,452	0.08	8,725	0.17	24,293	0.25	41,356	0.58	82,826
	Engineers 2												-	-
	Student 1												-	-
	Student 2												-	-
	Materials&supplies			5,000		40,000		15,000		45,000		10,000		115,000
	Consultant services			10,000		40,000		40,000		30,000		15,000		135,000
	Travel													-
	Total Direct		0.17	32,152	0.58	141,893	0.58	118,989	0.67	157,314	0.75	127,209	2.75	577,557
	Indirect			25,994		95,105		91,874		112,616		120,505		446,094
	Total		0.17	58,146	0.58	236,998	0.58	210,863	0.67	269,930	0.75	247,714	2.75	1,023,651
6.2.1.1	**Strips Mechanical**													
	Technician 1	Tom Johnson	0.08	8,576	0.08	8,871	0.08	9,173	0.08	9,631	0.08	10,101	0.40	46,352
	Technician 2												-	-
	Engineers 1												-	-
	Engineers 2												-	-
	Student 1												-	-
	Student 2												-	-
	Materials&supplies					15,000		10,000		10,000		10,000		45,000
	Consultant services													-
	Travel													-
	Total Direct		0.08	8,576	0.08	23,871	0.08	19,173	0.08	19,631	0.08	20,101	0.40	91,352
	Indirect			11,476		14,763		14,015		14,407		14,806		69,467
	Total		0.08	20,052	0.08	38,634	0.08	33,188	0.08	34,038	0.08	34,907	0.40	160,819
6.2.2	**Staves Electrical**													
	Technician 1	Bryan Holmes			0.13	14,850	0.08	10,180	0.08	10,683	0.08	11,205	0.37	46,918
	Technician 2	Machinist			0.13	11,619	0.08	7,965	0.08	8,358	0.08	8,767	0.37	36,709
	Engineers 1												-	-
	Engineers 2												-	-
	Student 1												-	-
	Student 2												-	-
	Materials&supplies					20,000		70,000		70,000		15,000		175,000
	Consultant services													-
	Travel													-
	Total Direct		0.00	0	0.25	46,469	0.16	88,145	0.16	89,041	0.16	34,972	0.73	258,627
	Indirect					35,622		35,650		36,412		26,064		133,748
	Total		0.00	0	0.25	82,091	0.16	123,795	0.16	125,453	0.16	61,036	0.73	392,375
6.2.3	**DAQ and Interfaces**													
	Technician 1												-	-
	Technician 2												-	-
	Engineers 1	John Joseph											-	-
	Engineers 2	Sergio Diez Cornell			0.50	37,601	0.13	9,201					0.63	46,802
	Student 1												-	-
	Student 2												-	-
	Materials&supplies					5,000		10,000		10,000		5,000		30,000
	Consultant services													-
	Travel													-
	Total Direct		0.00	0	0.50	42,601	0.13	19,201	0.00	10,000	0.00	5,000	0.63	76,802
	Indirect					31,539		9,497		2,026		1,013		44,075
	Total		0.00	0	0.50	74,140	0.13	28,698	0.00	12,026	0.00	6,013	0.63	120,877
6.2.4	**Alternative Powering**													
	Technician 1	Tom Johnson											-	-
	Technician 2												-	-
	Engineers 1	Joe Silber											-	-
	Engineers 2	Eric Anderssen											-	-
	Student 1												-	-
	Student 2												-	-
	Materials&supplies					5,000		5,000		5,000		5,000		20,000
	Consultant services													-
	Travel													-
	Total Direct		0.00	0	0.00	5,000	0.00	5,000	0.00	5,000	0.00	5,000	-	20,000
	Indirect					1,013		1,013		1,013		1,013		4,052
	Total		0.00	0	0.00	6,013	0.00	6,013	0.00	6,013	0.00	6,013	-	24,052
	LBNL Total		**0.25**	**78,198**	**1.41**	**437,876**	**0.95**	**402,557**	**0.91**	**447,460**	**0.99**	**355,683**	**4.51**	**1,721,774**

Table C-2: LBNL Stave Development Summary Budget

<u>Yale University</u>: **Statement of Work and Budgets**

WBS 6.2.1. Yale will work in area of strip stave mechanics and cooling. Yale will collaborate closely with BNL. The annual tasks follow.

2011: Yale will provide thermo-fluid and structural simulation modeling support to BNL to verify existing stave designs and to provide a cross-check of other simulation software available to both Yale and BNL. Yale in cooperation with BNL will initiate both thermal and structural property characterizations of advanced detector materials. Existing facilities (thermal imaging camera, Instron mechanical testing machine) at Yale will be utilized. Yale will begin construction of an open-loop CO_2 cooling system to be used at Yale and BNL to evaluate CO_2 as an option for detector cooling.
2012: Yale will supply carbon-foam/tube assemblies to BNL for ongoing detector stave development. Yale will continue with advanced detector material property characterization. Yale in concert with BNL will seek to understand foam-pipe interface reliability under thermal stress. Existing facilities (environmental chamber, thermal imaging camera, CO_2 cooling system) at Yale/BNL will be employed to that end. Previous advanced detector development has demonstrated a need for optimized carbon fiber composite cylindrical closeouts. Yale/BNL will contact local commercial composite manufacturers to assure that such items can be procured.
2013: Yale with BNL and LBNL will work on a more ambitious stave core with the goal of aggressively reducing mass. Our fully developed thermo-fluid and structural simulations will be primary tools for exploring various options. It is foreseen that a fully instrumented stave with deep sub-micron ASICS will be built; either this aggressive stave core will be used for the stave, or the more conservative design developed in 2011-2012 will be used and built by BNL/Yale. Yale will continue with material property characterization. Yale/BNL will develop with industry a prototype of the optimized carbon fiber cylindrical closeout. BNL/Yale will develop prototype PEEK-carbon fiber detector support brackets.
2014: Yale/BNL will continue to develop advanced stave core. Yale/BNL will develop a comprehensive detector quality assurance plan along with specific techniques for performing each QA step. Yale/BNL will streamline and simplify stave core assembly to a point that large scale assembly can be initiated. Specifically, assembly fixtures and parallel workstations will be designed and developed to this end.
2015: Yale/BNL will complete a final analysis of the stave design and provide documentation in the form of a technical report and drawings. Yale/BNL will finalize the quality assurance plan.

Budget Justification - Yale University's research program in partnership with Brookhaven National Laboratory will be a combination of thermo-fluid and structural simulations, detector stave prototype development, stave cooling evaluation, material property characterization and stave support design and prototyping. As such, 0.7 FTE (mechanical engineer) and 0.65 FTE (senior technician) will be required to complete this program.
2011: Engineer will work on developing complementary thermal and mechanical model of recently-fabricated large stave. Furthermore, engineer will initiate thermal and structural property characterization of advanced detector materials. Technician will fabricate test fixtures. Engineer and technician will fabricate and test open-loop CO_2 cooling system.
2012: Engineer will continue with material property characterization. Engineer will design a series of tests to evaluate tube-carbon foam interface during and following temperature cycling. Engineer will work with local vendors to design and develop optimized stave cylindrical closeouts. Technician will fabricate and assemble carbon foam-tube components as needed. Technician will fabricate fixtures and conduct tests to evaluate foam-pipe interface.
2013: Engineer will complete material property characterization. Engineer will conduct thermo-fluid and structural analyses to develop optimal (reduced mass) stave core designs. Engineer will complete procurement of cylindrical carbon composite closeout prototype. Technician will fabricate stave tooling, molds for support bracket fabrication and will assemble stave components as required.

2014: Engineer will modify assembly tooling design as required for advanced stave core. Engineer will develop a comprehensive detector stave quality assurance plan. In addition, engineer will develop a scaled-up stave assembly procedure. Technician will fabricate fixtures for high-volume stave core assembly and will produce stave cores as required.
2015: Engineer will work with BNL to document results of stave development program and will finalize quality assurance plan. Technician will assist in documentation preparation and will conduct thermal and structural testing of the final design.

Yale University Budget (AY$) for Collider Detector Program Proposal

		FY2011		FY2012		FY2013		FY2014		FY2015		Total	
WBS	Tasks & Resources	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested
6.2.1	**Strips Mechanical**												
	Tom Hurteau	-	-	0.65	53,300	0.65	54,300	0.65	55,500	0.65	56,700	2.60	219,800
	William Emmet	-	-	0.70	86,500	0.70	88,200	0.70	90,000	0.70	91,800	2.80	356,500
	Student 1	-	-	0.30	11,125	-	11,844	-	12,760	-	12,650	0.30	48,379
	Materials&supplies	-	20,500	-	19,500	-	21,000	-	19,000	-	20,000	-	100,000
	Travel	-	-	-	1,575	-	1,656	-	1,740	-	1,850	-	6,821
	Total Direct	-	20,500		172,000		177,000		179,000		183,000	-	731,500
	Indirect	-	-		-		-		-		-		-
	Yale Total	**-**	**20,500**	**1.65**	**172,000**	**1.35**	**177,000**	**1.35**	**179,000**	**1.35**	**183,000**	**5.70**	**731,500**

Table C-3: Yale University Stave Development Summary Budget

<u>Duke University</u>: Statement of Work and Budgets

WBS 6.2.2. Duke will set up an HSIO-DAQ test stand to help test various chip, module, and stave concepts being developed by collaborating institutions. This will be done in close coordination with BNL, LBNL, Penn, and UCSC. The additional infrastructure needed for module and stave tests will be acquired after the HSIO test stand is up and running.
2011: We will set up an HSIO-DAQ test stand. With most of the parts in hand this is currently in progress and will be completed by the summer of 2011. We are involving Duke students who will receive summer stipends funded by a Duke internal grant. Although not guaranteed, we are hoping for continued support from Duke for students to contribute to the project. Once set up we will get a single chip card up and running and gain some experience with DC-DC and serial power tests, and power protection schemes.
2012: We will continue helping with single chip power and power protection tests, and evaluating noise performance. With input from BNL, LBNL, Penn, and UCSC we will develop the infrastructure and expertise needed for hybrid and module tests. Potentially, in collaboration with Penn, we will help with chip evaluation (the new ABC chips will come out by the Spring of 2012). This will be contingent on local access to, or the acquisition of, a probe station capable of supporting 8 inch wafers.
2013-2015: We will continue chip, hybrid, module, and possibly stave tests, as determined by the needs of the project and in coordination with BNL, LBNL, Penn, and UCSC.

Budget Justification - Our requested funds are for travel and a 50% FTE technician starting in 2012. Equipment costs for the setting up of the Duke HSIO testing station (HSIO and interface board, computer, power supplies, and other peripherals) has been provided by an internal Duke grant obtained by the Duke PI's. We are anticipating future equipment needs to also be provided by Duke support, presuming the success of the project. Domestic travel is for coordination of activities with BNL and Penn. We are also requesting some international travel for meetings and workshops for one person once per year. For 2011 our request is for travel, for two trips to BNL to help them in setting up the HSIO test stand.

Duke University Budget (AY$) for Collider Detector R&D Program Proposal

		FY2011		FY2012		FY2013		FY2014		FY2015		FY2015	
WBS	Tasks & Resources	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested
6.2.2	**Stave Electrical Assembly & Test**												
	Labor	-	-	0.50	59,346	0.50	60,773	0.50	61,988	0.50	63,228	2.00	245,335
	Travel	-	4,000	-	8,000	-	8,000	-	8,000	-	8,000	-	36,000
												-	-
	Duke Total	-	4,000	0.50	67,346	0.50	68,773	0.50	69,988	0.50	71,228	2.00	281,335

Table C-4: Duke University Stave Development Summary Budget

<u>The University of Pennsylvania</u>: Statement of Work and Budgets

WBS 6.2.3. An on-going effort, based at CERN, focuses on the design of ASICs aimed at future high luminosity hadron colliders. Penn is an active participant in this and the effort connects directly with the goals and requirements of the proposed stave R&D. Two chips are under development, the ABC130, a 256 channel Front End ASIC that processes the strip signal and records hits over a programmable threshold, and the Hybrid Controller Chip (HCC) responsible for the interface between the DAQ readout and ten ABC130 ASICs. Penn will have lead responsibility for organizing the effort to design a 130nm HCC. For analog blocks we will attempt to re-use and adapt existing I/O blocks, DLL and power-up reset blocks. We also will finish the development of an HCC based autonomous voltage and temperature monitoring block in Q1 2012. In the digital domain we will take advantage of expert help available from UCSC and RAL to code Verilog behavioral blocks and make them suitable for silicon compiler input in 2012. In addition to work on the HCC we propose to validate Verilog models of a rad tolerant memory generator under development at CERN using SPICE (Fall 2011) this is crucial since the low power memory is expected to have a maximum clocking rate of about 80MHz. We intend to stay current with and cross check the Verilog models of the readout and control architecture using student help (masters and undergrad) from our engineering school.

We will use our IMS (400MHz I/O) IC tester for initial validation of the HCC design (Q3,2012) and expect to participate in system tests and in the revision of the design as necessary in the following year working towards a next generation chip set to be submitted in Q1, 2014. This will allow the latest possible input from the physics community on triggering and data throughput to influence the architecture. Another important part of our contribution will be to provide analog expertise in the design and testing of the grounding and shielding strategy for the stave systems working at BNL, LBNL (or at international collaborators) as necessary.

Budget Justification - Penn's participation in the strips readout architecture group and leadership in the development of the Hybrid Controller Chip (HCC) will rely heavily on the experience of Mitch Newcomer and Nandor Dressnandt. As a team they have been working together on the design of ASICs since the early 1990's. Recent work includes collaboration with the CERN microelectronics group in the design of the DTMROC ASIC for the TRT (2004) and the ABCn ASIC (2008) for the upgrade of the Silicon Strip Readout. We are asking for salary coverage for each at two months per year along with a $500/year to cover help from undergraduates. In order to stay current with the project it will be necessary to travel at least once per year to Europe and once domestically to BNL for a workshop or meeting. Since there will be some synergy with other projects we have limited the travel request to about $1900 per year.

In 2012 we are asking for sufficient funds to cover fabrication of the HCC in a CMOS8RF 130nm Multi-Project Wafer submission. The $24000 requested would cover a 7.5 mm^2 ASIC. We won't know the actual size for about a year, but given the size of the logic readout, buffers and monitoring, we expect that this is a minimum area for the HCC prototype.

WBS 6.2.4. The Penn effort will focus on the control and monitoring of serially powered staves. Initially we will test a prototype analog control unit (SCP) returned to us in Q1, 2011 that was fabricated on a die shared with CERN in the CMOS8RF 130nm process. Submission of a complete Serial Power and Protection prototype chip (SPP1) is projected for Q2 2011. Although not designed with special radiation tolerant layout due to the lack of design kit support, this chip is expected to enable realistic testing of the serial power approach with autonomous shut down and remote addressable power control. If successful we will move to a radiation tolerant version and add a remotely programmable coarse hybrid voltage adjustment (SPP2), submitting the revised chip in Q1 or Q2 2012. For the final version, in Q1, 2014 of the chip we are investigating a trigger for an SCR like power down failsafe function.

We will work in collaboration with BNL and UCSC to help with the integration of the selected powering scheme starting in 2012. This will include a careful study of the power routing, filtering and shielding techniques required to limit conducted and radiated EMI in the supply services on the stave. Finally, we will work with BNL and UCSC to develop an ASIC based addressable HV distribution system in 2013 to 2014 intended to reduce the number independent HV sensor cables by nearly an order of magnitude.

Budget Justification - Penn is presently the primary developer of the highly successful distributed shunt Serial Powering control for strip readout. To make Serial Powering robust we are developing a Serial Power and Protection Chip (SPP) that will both provide shunt regulation control and remotely addressable protection. We are requesting $14000 in 2011 for the fabrication of a prototype based on a recent budgetary estimate emailed to us by Kostas Koulias at CERN on March 3, 2011. An additional $1000 is requested to cover the cost of a chip on board PCB to test the SPP. After testing the concept with the 2011 prototype we will design a rad hard version with some additional features. Since these changes are likely to increase the area of the SPP we are requesting $24,000 for this ASIC plus $1000 to cover the cost of a test board. Mitch Newcomer and Nandor Dressnandt will spend between 1 and 1.5 months per year working on the ASIC design and implementation. Godwin Mayers, a skilled technician will spend about 1 month per year making test fixtures and small PC boards for testing SPP ASICs and interface electronics to drive the SPP chip. We will also ask $500 per year for the invaluable help of undergrads to perform tests and run simulations. Although we will work occasionally on Serial Powering at other institutions such as RAL or Liverpool, our main focus will be at BNL where we will make an estimated 4, $400 trips per year.

University of Pennsylvania Budget (AY$) for Collider Detector Program Proposal

			FY2011		FY2012		FY2013		FY2014		FY2015		Total	
WBS	Task & Resources	Personnel	FTE	Cost	FTE	Cost	FTE	Cost	FTE	Cost	FTE	Cost	FTE	Cost
6.2.3	**DAQ and Interfaces**													
	Engineer 1	Mitch Newcomer	0.08	10,451	0.17	21,529	0.17	22,174	0.17	22,840	0.17	23,525	0.75	100,519
	Engineer 2	Nandor Dressnandt	0.17	7,486	0.17	15,422	0.17	15,884	0.17	16,361	0.17	16,851	0.83	72,005
	Technician 1	Godwin Mayers												
	Technician 2	Mike Reilly												
	Paid Part Time Students		0.00	500	0.00	500	0.00	500		500		500	-	2,500
	Fringe Benefits			5,591		11,466		11,809		12,161		12,525	-	53,552
	Travel			-		1,900		1,900		2,000		1,500	-	7,300
	M&S			-		25,000		-		-		-	-	25,000
	Total Direct		0.25	24,028	0.33	75,817	0.33	52,267	0.33	53,862	0.33	54,901	1.58	260,876
	Total Indirect			14,417		30,490		31,360		32,317		32,941	-	141,525
	TOTAL Section		0.25	38,445	0.33	106,307	0.33	83,627	0.33	86,179	0.33	87,842	1.58	402,401
6.2.4	**Alternative Powering**													
	Engineer 1	Mitch Newcomer	0.08	10,451	0.13	16,146	0.13	16,631	0.13	17,130	0.08	11,762	0.54	72,120
	Engineer 2	Nandor Dressnandt	0.08	7,486	0.13	11,566	0.08	7,942	0.08	8,180	0.08	8,426	0.46	43,600
	Technician 1	Godwin Mayers	0.08	4,474	0.08	4,608	0.08	4,746	0.08	4,889	0.08	5,035	0.42	23,752
	Technician 2	Mike Reilly									0.08	3,631	0.08	3,631
	Paid Part Time Students			-		500		500		500		500	-	2,000
	Full Time Benefits			6,925		10,036		9,108		9,380		8,965	-	44,414
													-	-
	Travel			600		1,600		1,600		1,600		1,600	-	7,000
	M&S			15,000		-		25,000		1,000		-	-	41,000
	Total Direct		0.25	44,936	0.33	44,456	0.29	65,527	0.29	42,679	0.33	39,919	1.50	237,517
	Total Indirect			18,561		26,674		24,916		25,607		23,951	-	119,709
	TOTAL Section		0.25	63,497	0.33	71,130	0.29	90,443	0.29	68,286	0.33	63,870	1.50	357,226
	U of Penn Total		**0.50**	**101,942**	**0.67**	**177,437**	**0.63**	**174,070**	**0.63**	**154,465**	**0.67**	**151,713**	**3.08**	**759,627**

Table C-5: University of Pennsylvania Stave Development Summary Budget

<u>SLAC National Accelerator Laboratory</u>: Statement of Work and Budgets

WBS 6.2.1. Being one of the very few places with a CO_2 cooling test stands, SLAC is well prepared to contribute to the thermal mechanical studies of the staves for pixel and strip detectors. The present open blow system is adequate for occasional tests, while a closed loop re-circulating system would be more appropriate for regular use for more extensive testing activities. Our main goal is to construct the closed loop CO_2 cooling system in the next two years and follow up to use it to performance variety of thermal mechanical test of staves of various types as the main angle for a broader engagement in the mechanical support structure design.

Budget justification:

2011: The main effort will be design and construction of closed loop CO_2 cooling test stand at SLAC. Some small number of mechanical prototype thermal tests will also take place at the present blow system.

2012: Complete and commission the close loop CO_2 cooling test stand. Improve the control and monitoring instrumentation. Carry out thermal-mechanical tests for variety of stave mechanical prototypes and test performance at cold temperatures for various electrical assembly of sensors and readout.

2013-2015: Continued thermal mechanical tests and explore mechanical support design concepts, properties of new support materials and mechanical integration issues. Participate in the larger cooling system design studies.

The travel during these years corresponds to one international workshop/conference.

WBS 6.2.3. The readout needs for the full strip stave level multi-channel systems can leverage the high bandwidth generic DAQ R&D originated at SLAC with the versatile multi-I/O HSIO board and the Reconfigurable Cluster Element (RCE) concept on ATCA platform, including the extensive associated software utilities. Only moderate additional efforts for strip stave interface design and fabrication, and firmware and software specific to this proposal to serve all test needs.

Budget justification:
The main activity will be the electrical engineering support for the strip stave off-detector readout and various electrical testing which will be continuing throughout the 5 year period. Some specific tasks at various times:
2011: Design the HSIO + RCE merger board as the main test stand driver
2012: Delivering to 6-7 test stands with 2nd generation DAQ hardware of HSIO+RCE merged board as the driver for the individual test stands. In addition, a stave-level test setup for multiple RCE DAQ readout will be assembled at one location.
2013: Fabrication of multi-Gb/s interface boards for stave level tests and investigation of utilization of RCEs for simpler test and calibration implementations.
2014: Full stave readout production hardware for at least two sites and possible upgrade of mezzanine cards for test stands.
2015: Full stave readout and calibration tests and possibly test beam.
The travel budget is intended for one international workshop/conference each year.

SLAC Stave Development Budgets (AY$) for Collider Detector R&D Program Proposal

		FY2011		FY2012		FY2013		FY2014		FY2015		Total	
WBS	Tasks & Resources	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested
6.2.1	**Development of thermal-mechanical Stave Cores and cooling/thermal management**												
	Marco Orlunno (mech eng)	0.08	14,100	0.10	18,800	0.10	18,800	0.10	19,400	0.10	20,000	0.48	91,100
	Jim MacDonald (mech tech)	0.05	6,900	0.05	6,900	0.05	6,900	0.05	7,100	0.05	-	0.25	27,800
	Total salary + fringes		21,000		25,700		25,700		26,500		20,000	-	118,900
	CO2 cooling test stand		40,000		20,000		10,000		10,000		10,000	-	90,000
	Misc. M&S		2,000		4,000		4,000		4,000		4,000	-	18,000
	Travel		-		2,500		2,500		2,500		2,500	-	10,000
	Total Direct		63,000		52,200		42,200		43,000		36,500	-	236,800
	Indirect		18,000		20,800		19,900		20,400		16,000	-	95,100
	Total	0.13	81,000	0.15	73,000	0.15	62,100	0.15	63,300	0.15	52,500	0.73	331,900
6.2.3	**DAQ from above activities**												
	David Nelson (elec eng)	0.08	17,200	0.15	34,400	0.15	34,400	0.15	35,400	0.15	36,400	0.68	157,800
	Pham Tung (elec tech)	0.05	6,000	-	-	-	-	0.05	6,100	-	-	0.10	12,100
	Total salary + fringes		23,200		34,400		34,400		41,500		36,500	-	170,000
	Test Stand hardware prototypes		-		35,000		20,000		35,000		1,000	-	91,000
	Misc. M&S		2,000		3,000		3,000		3,000		3,000	-	14,000
	Travel		-		2,500		2,500		2,500		2,500	-	10,000
	Total Direct		25,200		74,900		59,900		82,000		52,000	-	293,900
	Indirect		15,700		28,000		26,600		32,800		27,000	-	130,100
	Total	0.13	40,900	0.15	102,800	0.15	86,400	0.20	114,800	0.15	79,000	0.78	424,000
	SLAC Stave Development Total	**0.25**	**121,900**	**0.30**	**175,800**	**0.30**	**148,500**	**0.35**	**178,200**	**0.30**	**131,500**	**1.50**	**755,900**

Table C-6: SLAC Stave Development Summary Budget

<u>The University of California at Santa Cruz</u>: Statement of Work and Budgets

WBS 6.2.2. UCSC will assemble and test "lean" sensor-ASIC modules, which will then be laminated onto the stave cores at BNL. Such modules have no extra support material beyond bare sensor, flex hybrid and ASICs. UCSC has the equipment and expertise necessary for this work having a state of the art wire bonder and the personnel who constructed large-scale silicon detectors such as the existing ATLAS SCT. The goal is to demonstrate that such modules can be efficiently made and handled in mass-production mode, as well as to supply the stave prototyping program with functional modules. The goal for 2011 is to verify our assembly process with dummy ASICs and sensors, and to make a few functioning modules. The goal for 2012-2015 is to ramp up the production speed and efficiency of making modules to demonstrate that a true module mass production is achievable with high yield. The exact number of constructed modules will be defined by the needs of stave construction and progress on its evaluation but approximately 80-100 are anticipated over the 5-year program.

Budget Justification – To complete this work, we require 16.7% (2 months) FTE per year level of effort of our experienced assembly technician to assemble the multi-chip readout hybrids and attach to sensors including the necessary wire bonding. We also require 8.3% FTE per year of our experienced electronics technician to carry out the testing of completed hybrids and modules. The final year will likely be devoted to follow-up testing and documentation. We anticipate \$3k/year required for miscellaneous assembly supplies (e.g. bond wire and epoxy) and jigs. The domestic travel (\$2k/year) is to visit collaborators at BNL to review assembly and test results especially as they affect stave integration. The first year FY11 is assumed to be an effective half-year in length and a 3% escalation factor is applied to each subsequent year.

WBS 6.2.3. UCSC personnel have participated for several years in the evolving design of possible readout architectures for these integrated detector geometries including the complexities they introduce such as very large data bandwidth, distributed broadcast clock and control signals and low power, low noise transmission over small radiation length media. This is a natural outgrowth of our previous involvement in readout designs for experiments such as BaBar and ATLAS. These architectural ideas now must be transformed into prototype ICs so that the full stave concept can be realized. Our experienced IC designer Joel DeWitt will work with the designers at Penn on a hybrid controller chip (HCC) and develop with our European collaborators a full set of readout ICs that can operate a complete stave. This likely will require two iterations of a full readout chip set to meet all performance requirements. In 2011 work will focus on block development and testing of prototypes followed by full chip design and submission in 2012. After detailed testing a second submission will likely be required in early 2014.

Budget Justification – This work requires 25% FTE per year level of effort of our experienced IC designer who will be collaborating closely with collaborators at U of Penn. We have included \$2k/year for CAD software licenses, the expense of which we share with other groups on campus, and another \$2k/year for miscellaneous equipment, for example maintenance or replacement of CAD hardware over the course of the 5-year program. The domestic travel (\$2k/year) is to visit collaborators at Penn. The first year FY11 is assumed to be an effective half-year in length and a 3% escalation factor is applied to each subsequent year.

WBS 6.2.4. One of the main challenges for integrated stave powering schemes is to ensure low noise pickup and low EMI. The UCSC group has particular expertise in grounding and shielding for silicon detector systems. E. Spencer designed the grounding and shielding scheme for the existing ATLAS SCT and provides similar guidance for the ATLAS IBL. His expertise will be applied to the designs for competing powering schemes for the integrated stave with an overview of cabling, stave cores, and ASICs. This will include contributions to the design of cabling and ICs in the 2011 and 2012, followed by evaluation of test results performed on the first integrated staves at BNL. We anticipate that these designs will evolve in 2013 and 2014 based on the experience with the first full electrical prototype staves.

Budget Justification – The proposed work requires 16.7% FTE (2 months) per year level of effort of our experienced electronics and system engineer who will be working closely with our collaborators at BNL and U of Penn. While most of the integrated stave testing will be done at BNL, we have included $5k/year for miscellaneous equipment required to conduct some specialized noise pickup and EMI testing at Santa Cruz. The domestic travel ($6k/year) is for travel to BNL to participate in the integrated stave testing. The first year FY11 is assumed to be an effective half-year in length and a 3% escalation factor is applied to each subsequent year.

UCSC Stave Budgets (AY$) for Collider Detector Program Proposal

WBS	Tasks & Resources	FY11 FTE	FY11 Funds Requested	FY12 FTE	FY12 Funds Requested	FY13 FTE	FY13 Funds Requested	FY14 FTE	FY14 Funds Requested	FY15 FTE	FY15 Funds Requested	Total FTE	Total Funds Requested
6.2.2	**Electrical assembly and test of staves and components**												
	Labor												
	G.F. Martinez-McKinney (Tech)	0.08	5,751	0.17	11,847	0.17	12,203	0.17	12,569	0.17	12,946	0.75	55,317
	M. Wilder (Tech)	0.04	2,981	0.08	6,141	0.08	6,325	0.08	6,515	0.08	6,711	0.38	28,674
	Total Salary & Fringe		8,732		17,989		18,528		19,084		19,657	-	83,990
	M&S (assembly & clean room supplies)		3,000		6,180		6,365		6,556		6,753	-	28,855
	Travel (1 domestic trip/year)		2,000		2,060		2,122		2,185		2,251	-	10,618
	Total Direct		13,732		26,229		27,016		27,826		28,661	-	123,464
	Base Subject to Indirect		13,732		26,229		27,016		27,826		28,661	-	123,464
	Indirect		3,570		6,819		7,024		7,235		7,452	-	32,101
	Total	0.13	17,303	0.25	33,048	0.25	34,040	0.25	35,061	0.25	36,113	1.13	155,564
6.2.3	**Development of multi-channel parallel data acquisition tools, interface and control circuits for stave readout**												
	Labor												
	J. DeWitt (Designer)	0.13	10,225	0.25	21,063	0.25	21,695	0.25	22,346	0.25	23,016	1.13	98,346
	Total Salary & Fringe		10,225		21,063		21,695		22,346		23,016	-	98,346
	M&S ($2k CAD licenses, $2k misc supplies per year)		2,000		4,120		4,244		4,371		4,502	-	19,237
	Travel (1 domestic trip/year)		2,000		2,060		2,122		2,185		2,251	-	10,618
	Total Direct		14,225		27,243		28,061		28,902		29,769	-	128,201
	Base Subject to Indirect		14,225		27,243		28,061		28,902		29,769	-	128,201
	Indirect		3,698		7,083		7,296		7,515		7,740	-	33,332
	Total	0.13	17,923	0.25	34,327	0.25	35,356	0.25	36,417	0.25	37,510	1.13	161,533
6.2.4	**Development and test of alternative power systems**												
	Labor												
	E. Spencer (EE)	0.08	9,085	0.17	18,715	0.17	19,277	0.17	19,855	0.17	20,451	0.75	87,382
	Total Salary & Fringe		9,085		18,715		19,277		19,855		20,451	-	87,382
	M&S (Misc supplies for testing)		2,500		5,150		5,305		5,464		5,628	-	24,046
	Travel (3 domestic trips/year)		6,000		6,180		6,365		6,556		6,753	-	31,855
	Total Direct		17,585		30,045		30,947		31,875		32,831	-	143,283
	Base Subject to Indirect		17,585		30,045		30,947		31,875		32,831	-	143,283
	Indirect		4,572		7,812		8,046		8,287		8,536	-	37,254
	Total	0.08	22,157	0.17	37,857	0.17	38,993	0.17	40,162	0.17	41,367	0.75	180,536
	UCSC Stave Development Total	**0.33**	**57,383**	**0.67**	**105,232**	**0.67**	**108,389**	**0.67**	**111,640**	**0.67**	**114,989**	**3.00**	**497,633**

Table C-7: UCSC Stave Development Summary Budget

Appendix D. Statements of Work and Budgets for New Calorimeter Readout and Trigger Systems (WBS 6.3)

Argonne National Laboratory: Statement of Work and Budgets

WBS 6.3.1. ANL has interest and expertise in two areas – power distribution system design, and radiation tolerance testing. We will work on the development of a 3 stage power distribution system, including bulk distribution of high voltage DC, intermediate conversion to 48V, and finally point-of-load regulators at the load. We will also provide expertise with radiation testing of components and subsystems, leveraging our experiences with Massachusetts General Hospital and the nuclear reactor at Lowell.
2011: We will begin the development of a new switch mode converter for the second stage of the 3-stage power system. In this period we will produce a first design, and begin development of the first prototype.
2012: In this period we will construct and build the first switch mode converter prototype. We will perform bench measurements at ANL. We will begin the radiation qualification testing of the selected parts in the design, using proton, neutron, and gamma irradiation. We will also begin tests with candidate point-of-load regulators.
2013: During this period, we will produce the design for a second prototype. We will fabricate the converter, and repeat our bench and radiation tests. We will select a point-of-load regulator, and begin the design of the full power distribution system.
2014: During this period, we will develop a small system capable of demonstrating the performance of the prototype power distribution system. We will use the developments of the other parts of this research program (WBS 6.3.x), and incorporate the power system into a complete system test.
2015: During this period, we will continue system tests with subsystems developed in this research program. We will aim at system tests with cosmic rays, and possibly a test beam. Design iterations may be required based on system performance in prior periods.

Budget Justification – The research program described above will require primarily the effort of an electronics engineer (EE) and a physicist (PHY) from ANL. Support effort from engineering assistants (EA) and electronics technicians (ET) will also be needed to build and test electronics boards. All effort levels quoted are in full-time equivalents (FTEs).
2011: Engineers will develop the first prototype design of a switch-mode power converter. Approximate effort required: 0.05 EE.
2012: Engineer and EA will produce the first prototype switch mode converter. A technician will be needed to assemble the boards. Engineers will perform measurements to characterize the new design. Approximate effort required: 0.20 EE, 0.10 EA, 0.10 ET. M&S costs will be ~$5K for test board and test stand development and $10K for radiation tests.
2013: Engineer and EA will produce the second prototype switch mode converter. A technician will be needed to assemble the boards. Engineers will perform measurements to characterize the new design. Approximate effort required: 0.20 EE, 0.10 EA, 0.10 ET. M&S costs will be ~$5K for test board and test stand development and $10K for radiation tests.
2014: Engineers will work with other groups to develop a demonstrator of the full power distribution system. Approximate effort required: 0.15 EE. M&S costs will be ~$5K.
2015: Engineers will work with other groups to finalize a demonstrator of the full power distribution system. Approximate effort required: 0.15 EE. M&S costs will be ~$5K.

WBS 6.3.3. ANL will be collaborating with Fermilab to develop a new version of the QIE – a high-performance front-end ASIC for use in high-rate colliding beam experiments. The research program includes the development, characterization, testing, and radiation certification of the new device. To date, two test devices have been designed and tested. The proposed research program begins at this point. Our anticipated annual research program follows:

2011: We will focus on the development of the first full version of the new QIE, designated QIE10C. We will work with the ASIC designers at Fermilab to specify the design, review the design, and participate in simulations. The chip would be submitted for fabrication to MOSIS through their Multi Project Wafer submission program in the fall of this year. The expected delivery would then be December, 2011.
2012: We will test the QIE10C at the bench at ANL. We will design a test board, construct a test stand, and write test and data analysis programs for these tests. The board will be designed so that it is capable of interfacing to a photo-multiplier tube. We will perform bench measurements on the chip to characterize the device. We will also perform radiation tests on the new device. By the latter part of the year, we will perform tests of the new chip with a photo-detector, possibly incorporating tests in a cosmic ray hodoscope at Argonne.
2013: During this period, we will specify the final changes to design of the chip. We will work with FNAL engineers to implement these changes, including participating in simulations and design review. We will fabricate of order ~50-100 chips again using MOSIS, and prepare for larger scale tests. We will repeat our bench measurements and cosmic ray tests during this period prior to building larger numbers of channels. This will require planning and development of a small readout system to interface to the new chip.
2014: During this period, we will develop a small system capable of instrumenting of order ~60 photo-multiplier tubes. We have access to a section of the ATLAS Hadronic Calorimeter (TileCAL), which resides in one of the labs at CERN. We will target this detector for out tests. We will design new front-end electronics based around the QIE, which interfaces to TileCAL. Using the chips that were fabricated in the previous year, we will initiate a small scale production of ~50 channels of electronics. We will instrument a TileCAL detector section at a CERN lab, and prepare for cosmic ray tests and test beam measurements.
2015: During this period, we will perform tests using the TileCAL detector section. We will first use this to measure cosmic rays. Later in the year, we will move the detector section and electronics to a test beam at CERN, and perform beam measurements. We will publish our results of these tests.

Budget Justification – The research program described above will require primarily the effort of an electronics engineer (EE) and a physicist (PHY) from ANL. Support effort from engineering assistants (EA) and electronics technicians (ET) will also be needed to build and test electronics boards. All effort levels quoted are in full-time equivalents (FTEs).
2011: Engineer and physicist will work with colleagues at FNAL to specify the QIE10C and perform simulations. ANL will provide support for the ASIC designer at FNAL. ANL will also procure the fabrication of chips from MOSIS. Approximate effort required: 0.75 EE, and 0.1 PHY. M&S costs will be ~$50K for chip fabrication.
2012: Engineer and EA will design a test board for the new QIE, and construct a test stand for measurements. Test and analysis programs will be developed by a physicist. A technician will be needed to assemble the boards. Engineer and physicist will perform measurements to characterize the new device, including measurements with the cosmic ray hodoscope and radiation tests. Approximate effort required: 0.50 EE, 0.50 PHY, 0.15 EA, 0.1 ET. M&S costs will be ~$20K for test board and test stand development and $10K for radiation tests.
2013: Engineer and physicist will work with FNAL to specify the changes to the chip and perform simulations. ANL will again provide support for the ASIC designer at FNAL. ANL will also procure the fabrication of chips from MOSIS. A new test board may be required, requiring EA and ET effort. Engineer and physicist will perform bench measurements on new chips. Approximate effort required: 0.5 EE, 0.25 PHY, 0.15 EA, 0.1 ET.
2014: Engineer and EA will perform final design a board for the QIE to interface to the TileCAL detector, including a back-end data acquisition board. Check out and analysis programs will be developed by a engineer and physicist. A technician will be needed to assemble the boards. Checkout will be performed by the EA for this small-scale production. Engineer and physicist will begin preparations for interfacing new electronics into the TileCAL detector. Approximate effort required: 1.0 EE, 0.50 PHY, 0.50 EA,

0.25 ET. M&S costs will be ~$50K for chip fabrication and ~$25K for the production of the electronics boards for the system.
2015: Engineer and physicist will perform measurements using the TileCAL detector section at CERN, both for cosmic rays and in a test beam. Approximate effort required: 0.25 EE, 1.0 PHY, 0.10 EA, 0.10 ET.

WBS 6.3.5./6.3.6. ANL has developed capabilities with ATCA, and has expertise in Trigger/DAQ systems. Our interest in this research program will be primary to ensure that the data concentrators and trigger signal formation are consistent with the electronics that we will develop in WBS 6.3.3. Our primary activities will be to work with other groups to develop specifications, review designs, and provide support in the testing of the system with the subsystems of WBS6.3.3.
2011: We will work with BNL, MSU, and Arizona in developing the specifications for the first data concentrator prototype.
2012: In this period we will review designs produced by MSU, BNL, and Arizona to ensure compatibility with front-end electronics development.
2013: During this period, we will test the prototype ROD with the electronics developed in WBS 6.3.3.
2014: During this period, we will continue testing the prototype RODs, with design iterations as needed. A goal is to prepare for a test beam in 2015.
2015: During this period, we will participate in test beam measurements using the RODs, as well as the electronics from WBS 6.3.3.

Budget Justification – The research program described above will require primarily the effort of an electronics engineer (EE), and engineering assistants (EA). All effort levels quoted are in full-time equivalents (FTEs).
2011: Engineers will work with collaborating groups to develop specifications. Approximate effort required: 0.15 EE. M&S costs will be ~$4K for evaluation parts.
2012: Engineers will review designs from collaborating institutions. Approximate effort required: 0.15 EE. M&S costs will be ~$5K for radiation tests.
2013: Engineers will perform measurements to characterize the new design. Approximate effort required: 0.15 EE.
2014: Engineers will work with other groups to develop system tests using the developments from WBS 6.3.3. Approximate effort required: 0.15 EE. M&S costs will be ~$5K.
2015: Engineers will work with other groups to prepare for test beam measurements of a full system slice. Approximate effort required: 0.15 EE. M&S costs will be ~$5K.

ANL Budget (AY$) for Collider Detector Program Proposal (Calorimetry Electronics)

		FY2011		FY2012		FY2013		FY2014		FY2015		Total	
WBS	Tasks & Resources	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested
6.3	**New Calorimeter Electronics Systems**												
6.3.1	**Readout Architecture and System Integration**												
	Gary Drake (Engineer)	0.02	4,596	0.05	12,064	0.05	12,667	0.05	13,301	0.05	13,966	0.22	56,594
	Pat DeLurgio (Engineer)	0.05	7,534	0.10	15,822	0.10	16,613	0.10	17,444	0.10	18,316	0.45	75,729
	Materials&supplies		4,000		5,000		5,000		5,000		5,000	-	24,000
	Travel		2,000		2,000		2,000		2,000		2,000	-	10,000
	Total Direct		18,130		34,886		36,280		37,744		39,282	-	166,322
	Indirect		7,252		13,954		14,512		15,098		15,713	-	66,529
	Total	0.07	25,382	0.15	48,840	0.15	50,792	0.15	52,842	0.15	54,994	0.67	232,851
6.3.3	**On Detector Digitization and Data Organization**												
	Caroline Jones (Technician)		0	0.10	11,555	0.10	12,133	0.30	38,218	0.10	13,376	0.60	75,282
	Tim Cundiff (Technician)		0	0.15	23,733	0.15	24,919	0.50	87,218	0.10	18,316	0.90	154,186
	Gary Drake (Engineer)	0.10	22,979	0.15	36,192	0.15	38,002	0.25	66,503	0.10	27,931	0.75	191,608
	Pat DeLurgio (Engineer)	0.25	37,671	0.35	55,377	0.35	58,145	0.50	87,218	0.15	27,474	1.60	265,885
	Engineer					0.10	16,613	0.15	26,165			0.25	42,778
	Materials&supplies		50,000		30,000		20,000		75,000		20,000	-	195,000
	Travel		6,000		6,000		6,000		6,000		6,000	-	30,000
	Total Direct		116,650		162,857		175,812		386,323		113,097	-	954,740
	Indirect		46,660		65,143		70,325		154,529		45,239	-	381,896
	Total	0.35	163,311	0.75	227,999	0.85	246,137	1.70	540,852	0.45	158,336	4.10	1,336,636
6.3.5	**Data Organization and Processing for the Presentation to the TDAQ System**												
	Caroline Jones (Technician)		0	0.10	11,555	0.10	12,133	0.10	12,739	0.10	13,376	0.40	49,803
	Tim Cundiff (Technician)		0	0.15	23,733	0.15	24,919	0.15	26,165	0.10	18,316	0.55	93,134
	Gary Drake (Engineer)	0.05	11,490	0.05	12,064	0.05	12,667	0.05	13,301	0.05	13,966	0.25	63,487
	Pat DeLurgio (Engineer)	0.10	15,068	0.10	15,822	0.10	16,613	0.10	17,444	0.10	18,316	0.50	83,263
	Materials&supplies		2,000		5,000		5,000		5,000		5,000	-	22,000
	Travel				2,000		2,000		2,000		2,000	-	8,000
	Total Direct		28,558		70,174		73,332		76,649		70,974	-	319,687
	Indirect		11,423		28,069		29,333		30,660		28,389	-	127,875
	Total	0.15	39,981	0.40	98,243	0.40	102,665	0.40	107,309	0.35	99,363	1.70	447,562
6.3.6	**Calorimeter Trigger Interface Demonstrator**												
	Caroline Jones (Technician)		0		0	0.10	12,133	0.10	12,739	0.10	13,376	0.30	38,248
	Tim Cundiff (Technician)		0		0	0.10	16,613	0.10	17,444	0.10	18,316	0.30	52,372
	Gary Drake (Engineer)		0	0.05	12,064	0.05	12,667	0.05	13,301	0.05	13,966	0.20	51,998
	Pat DeLurgio (Engineer)	0.05	7,534	0.10	15,822	0.10	16,613	0.10	17,444	0.10	18,316	0.45	75,729
	Materials&supplies						5,000		5,000		5,000	-	15,000
	Travel								2,000		2,000	-	4,000
	Total Direct		7,534		27,886		63,026		67,927		70,974	-	237,347
	Indirect		3,014		11,154		25,210		27,171		28,389	-	94,939
	Total	0.05	10,548	0.15	39,040	0.35	88,236	0.35	95,098	0.35	99,363	1.25	332,286
	ANL Calorimeter Electronics Total	**0.62**	**239,222**	**1.45**	**414,123**	**1.75**	**487,832**	**2.60**	**796,101**	**1.30**	**412,056**	**7.72**	**2,349,334**

Table D-1: ANL Calorimeter Electronics Summary Budget

University of Arizona: Statement of Work and Budgets

The specific work plan for digital data concentrator R&D follows. In FY11-FY13 we plan to build AMC format modules running at 10 Gbps. The AMC modules will perform digital signal processing and trigger tower building for four on-detector Readout Boards (ODRBs). With small design modifications, AMC format modules will also be made into AMC format injectors that are necessary for extensive testing of the AMC modules themselves. The University of Arizona will focus on AMC format modules using

Altera FPGAs and keep at the forefront of the telecommunication industry in terms of high speed and density optical links. Several prototypes of AMC modules will be constructed during FY11-FY13. In terms of firmware development, Arizona will focus on the digital signal processing of the ODRBs data (in collaboration with BNL). We will also work on the numerous outstanding architectural questions including designs with lower speed optical links and alternative digital signal processing algorithms during this period (in collaboration with BNL).

Our budget request for this period (FY11-FY13) includes partial salary support for electrical engineer (EE) Joel Steinberg who has worked in the telecommunications industry and has extensive experience with optical links and high density FPGA's. In FY11-13 he is supported at 25%, 50%, and 33% FTE respectively reflecting his projected workload. We have had good success using electrical engineering undergraduates to perform the tasks of an electrical technician including simple layout, assembly, testing, and firmware development. We request EE undergraduate salary support for 38%, 60%, and 60% FTE during this period. The students are very cost effective electrical technicians. Our present student technicians on this project are Shuai Chang and Charlie Armijo. The M&S costs include three iterations of prototype AMC modules and test fixtures to power and probe them. The costs are based on the material costs of earlier prototypes. In FY13 we will build four AMC modules (comprising one digital data concentrator) hence the higher M&S costs. One trip to BNL each year starting in FY12 is also requested for the EE.

In FY14 the University of Arizona will focus on the rear transition module needed to send data to the L1 trigger. We request EE support (33% FTE) and EE undergraduate support (60% FTE) to design, build, and test a prototype rear transition module. Continued development of firmware for the AMC modules will also continue during this period.

In FY15 we will produce a complete prototype digital data concentrator consisting of the ATCA carrier board, four AMC modules, and a rear transition module. We request EE support (33% FTE) and EE undergraduate support (60% FTE) to build and test the final digital data concentrator prototype (except the ATCA carrier board). The final prototype requires four AMC modules resulting in higher M&S costs. We also envision a complete slice test of the full electronics chain to be demonstrated at CERN. Thus we request one trip to CERN for the EE in FY15.

The major milestones for this project are:
9/30/11 - First prototype design for 10 Gbps AMC module complete
9/30/12 - Working prototype of 10 Gbps AMC module exists
9/30/13 - Final design and prototype of AMC module complete
- Preliminary firmware for AMC modules including digital signal processing and trigger tower building complete

9/30/14 - Prototype rear transition module complete
9/30/15 - Final prototype digital data concentrator complete

University of Arizona Budgets (AY$) for Collider Detector R&D Program Proposal (Calorimeter Electronics)

WBS	Tasks & Resources	FY2011 FTE	FY2011 Funds Requested	FY2012 FTE	FY2012 Funds Requested	FY2013 FTE	FY2013 Funds Requested	FY2014 FTE	FY2014 Funds Requested	FY2015 FTE	FY2015 Funds Requested	Total FTE	Total Funds Requested
6.3.1	**Readout Arch & System Integr**												
6.3.5	**Data organization & processing**												
6.3.6	**Calorimeter Trigger interface**												
	Joel Steinberg	0.25	28,744	0.50	57,487	0.33	38,325	0.33	38,325	0.33	38,325	**1.74**	**201,206**
	EE undergraduates	0.38	8,189	0.50	12,739	0.60	12,739	0.60	12,739	0.60	12,739	**2.68**	**59,145**
	Total Salary & Fringe		36,933		70,226		51,064		51,064		51,064		**260,351**
	M&S (prototype and test fixtures)		10,000		21,000		37,000		10,000		40,000		**118,000**
	Travel (to BNL)		-		900		900		900		900		**3,600**
	Travel (to CERN)		-		-		-		-		1,500		**1,500**
	Total Direct		46,933		92,126		88,964		61,964		93,464		**383,451**
	Base Subject to Indirect		46,933		92,126		88,964		61,964		93,464		**383,451**
	Indirect (26%)		12,203		23,953		23,131		16,111		24,301		**99,697**
	Unif of Arizona Total	**0.63**	**59,136**	**1.00**	**116,079**	**0.93**	**112,095**	**0.93**	**78,075**	**0.93**	**117,765**	**4.42**	**483,148**

Table D-2: University of Arizona Calorimeter Electronics Summary Budget

Brookhaven National Laboratory: Statement of Work and Budgets

WBS 6.3.1. Readout architecture and system integration: BNL will lead the design of the readout architecture and the effort on system integration. BNL has played a leading role in the readout architecture design and system integration of the current system. The system integration will address all the issues necessary to operate the electronics reliably conforming to the standards imposed by the ATLAS experiment. The goals of FY2011-2012 are to define the readout architecture and specify the electronics design requirements. The goals of 2013-2015 are to prototype a small scale front end board, address system integration issues such as grounding and EMI/EMC and design a power distribution based on point of load converters. This work will be performed at the installations used for the integration of the current system at BNL and we will profit from the test equipment and expertise in hands. As the front end board will be operated in a radiation environment, BNL will take the lead in establishing testing and qualification procedures for devices for the ATLAS specific radiation environment. These tests will be conducted at BNL for ionizing radiation, neutrons at LANSCE (Los Alamos), and protons at the Massachusetts General Hospital.

Budget Justification - We will require an effort at the level of 0.2 electrical engineering FTE for system integration activities and radiation test procedure development. Equal level of funding is requested for Mechanical Technician FTE to help on the update of mechanical infrastructure for test rigs and cooling system. Travel funds is for participation of systems integration and radiation testing meetings at CERN, and to use the radiation testing facilities. We also request funds to purchase components, develop small test boards, probes, for electronics testing and fitting, hoses, pipes, mechanical structure for the test laboratory update.

WBS 6.3.2. Analog signal conditioning and noise optimization: BNL will participate the design and noise optimization of the analog front end ASIC, which includes preamplifier and shaper. The goal of 2011-2012 is to prototype a preamplifier with Germany's IHP SG25H3p SiGe process and test it with the existing IBM 8WL prototype shaper. The goal of 2013-2015 is to prototype shaper with IHP process after the validation of the process with preamplifier bench test, different processes (IBM 7WL, AMS) will also be considered.

Budget Justification - For this activity we will require an effort at the level of 0.1 EE FTE and 0.1 FTE for the testing at BNL of the ASICs being developed. The travel funds are to (foreign) participate in meetings at CERN to discuss progress of the R&D together with other members of the Liquid Argon collaboration. The domestic travel is for participate in meetings at University of Pennsylvania and also for radiation testing of ASICS. We also needs the manufacturing of small boards, purchase components, for testing of ASICS.

WBS 6.3.3. On detector digitization and data organization: BNL will participate in the design of the on detector digitization and data organization. UBNL will seek alternative solutions to the radiation hard ADC being developed. The strategy will be to seek help from different vendors and work with them on establishing the feasibility of using their devices in the ATLAS specific radiation environment. BNL has expertise on high speed, high density signal digitization and organization design. Boards with 64 channels, 65MSPS ADC have been designed and prototyped. The goal of FY2011-2012 is to define the requirements of the on detector signal digitization and data organization. In FY2013-2015 we will work on the design and testing of a front end board prototype.

Budget Justification - This effort will require 0.2 FTE/year in EE-FTE for the development test boards and radiation tests. 0.1 MT FTE is required to prepare text fixtures. We only request domestic travel funds that will be used for radiation tests and visit to potential vendors. We request funds for the purchase of components, board manufacturing, cabling, for test fixtures.

WBS 6.3.5. Data organization and processing for presentation to the DAQ system: In the new readout architecture, Readout Processing Board (RPB) is a critical part which has to receive large amount of data and process in real time for presentation to the DAQ system. BNL has demonstrated the 12x6.25Gbps parallel optical link for data transmission on RPB in collaboration with Univ. of Arizona. The goal of FY2011-2013 is to design an AMC format RPB module running at 12x10Gbps, we will use Xilinx FPGA and Avago 12-channel parallel optical transceiver, each AMC module will process data from four front end boards. In FY2014-2015, BNL will design the RPB carrier board which will house four AMC RPB modules, each RPB board will process data from sixteen front end boards. BNL will also work on the data processing on RPB for energy and timing reconstruction, and data preparation to the DAQ system.

Budget Justification - BNL, University of Arizona and Stony Brook University are the key players on this R&D item. At BNL we estimate that we require a 0.4 EE-FTE for the design, testing and system evaluation. We will also require ET and MT support at the level of 0.3 FTE for board design, manufacturing, and for the preparation of electrical and mechanical test fixtures. Since this activity will also be done in conjunction with European colleagues we request mostly foreign travel funds for the participation in meetings at CERN. We will be requiring funds for the purchase of components, board manufacturing, computer software license for FPGA development, probes and development kits.

WBS 6.3.6. Calorimeter trigger interface: The proposed new readout architecture requires extremely large amount of data to be organized, processed in real time, and form the trigger primitives for L1 trigger system. BNL will participate the design of the calorimeter trigger interface. We will use the ATLAS Liquid Argon calorimeter as basis of development. The Trigger Primitive Builder board (TPB) will be upgraded to include the digital readout. The goals of the proposed activity is to have a system (see **Figure D-1**) that we can test at the BNL mockup installation by the end of FY 2012. In FY2013 and FY2014 we will build a prototype and commission it and ready it to be tested in the ATLAS liquid argon calorimeter by 2015. At this later stage we will integrate new TPB with RDB which will receive and process data, prepare coarse trigger tower (e.g. 0.1x0.1) information to L1 calorimeter trigger to minimize the latency (< 3.0us).

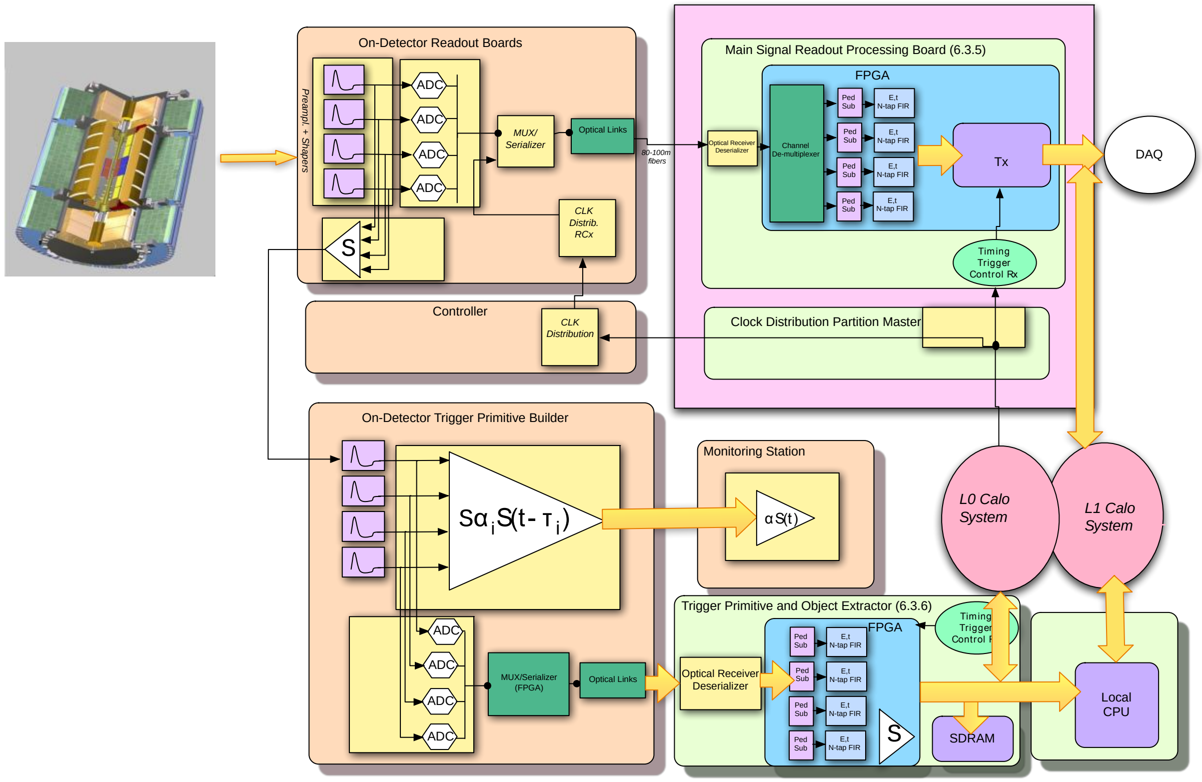


Figure D-1: Readout and Trigger Interface demonstrator conceptual block diagram

Budget Justification - BNL is the lead institution on this item. The new TPB will be developed at BNL and the estimated level of effort is 0.3 EE FTE for board design and prototype testing. We will also require ET and MT at a level of 0.2 FTE for board design and fabrication, manufacturing of test fixtures, prepare boards, cabling and ancillary equipment for tests. We are requesting travel funds to participate in meetings and to evaluate the board in situ at CERN. The domestic travel funds will be used for radiation tests of components and to support visiting faculty. We plan on inviting Dr. Wilfred Cleland who actively worked on the TPB currently in use to help with his expertise in the systems evaluation of the proposed system. The material purchases are based on estimates for the building and commissioning of a prototype unit capable of operations at the current front end crate.

BROOKHAVEN NATIONAL LABORATORY
PHYSICS DEPARTMENT
COST PLAN PROPOSAL

Budget Plan Dept Code: PO
Revision Id: CURRENT REVISION 1
Budget Plan Id: BNL WBS 6.3.1

	FY 2011	*FY 2012*	*FY 2013*	*FY 2014*	*FY 2015*	*TOTAL 5 YEARS*
COST PLAN	**40,531.37**	**122,193.35**	**125,856.46**	**129,658.78**	**138,157.75**	**556,397.71**
050 - Base Salary	15,546.53	59,100.91	61,346.74	63,677.92	66,097.68	265,769.78
SALARY	**15,546.53**	**59,100.91**	**61,346.74**	**63,677.92**	**66,097.68**	**265,769.78**
280 - Foreign Travel	2,000.00	4,000.00	4,000.00	4,000.00	8,000.00	22,000.00
290 - Domestic Travel	0.00	3,000.00	3,000.00	3,000.00	2,000.00	11,000.00
300 - PO Purchases	8,000.00	10,000.00	10,000.00	10,000.00	10,000.00	48,000.00
MSTC-LV	**10,000.00**	**17,000.00**	**17,000.00**	**17,000.00**	**20,000.00**	**81,000.00**
251 - Electric - Distributed	298.49	1,134.74	1,177.86	1,222.62	1,269.08	5,102.79
OTH-EXEMPT	**298.49**	**1,134.74**	**1,177.86**	**1,222.62**	**1,269.08**	**5,102.79**
700 - Organizational Burden	1,958.86	7,446.71	7,729.69	8,023.42	8,328.31	33,486.99
DEPT-CHRGS	**1,958.86**	**7,446.71**	**7,729.69**	**8,023.42**	**8,328.31**	**33,486.99**
705 - LDRD Burden	1,405.27	4,228.38	4,354.82	4,486.07	4,781.30	19,255.84
710 - G&A Burden	2,318.77	6,977.12	7,185.76	7,402.33	7,889.47	31,773.45
720 - Common Support	7,700.81	23,171.29	23,864.18	24,583.39	26,201.26	105,520.93
725 - IGPP Burden	702.63	2,114.19	2,177.41	2,243.03	2,390.65	9,627.91
745 - Procurement	600.00	1,020.00	1,020.00	1,020.00	1,200.00	4,860.00
LABWIDE-OH	**12,727.48**	**37,510.98**	**38,602.17**	**39,734.82**	**42,462.68**	**171,038.13**
050 - PROF4 - 14676 - KIERSTEAD ,JAMES	0.10	0.10	0.10	0.10	0.10	0.50
050 - SCI3 - 17504 - RESCIA ,SERGIO	0.00	0.10	0.10	0.10	0.10	0.40
050 - TECH3 - 20703 - FARRELL ,JASON	0.00	0.10	0.10	0.10	0.10	0.40
050 - TECH4 - 15299 - HOFFMANN ,AUGUST	0.00	0.10	0.10	0.10	0.10	0.40
TOTAL PERSONNEL	**0.10**	**0.40**	**0.40**	**0.40**	**0.40**	**1.70**

Budget Plan Dept Code: PO
Revision Id: CURRENT REVISION 1
Budget Plan Id: BNL WBS 6.3.2

	FY 2011	*FY 2012*	*FY 2013*	*FY 2014*	*FY 2015*	*TOTAL 5 YEARS*
COST PLAN	**37,063.62**	**76,142.24**	**78,107.27**	**79,994.34**	**82,111.55**	**353,419.02**
050 - Base Salary	18,071.98	31,703.95	32,908.70	34,159.23	35,457.28	152,301.14
SALARY	**18,071.98**	**31,703.95**	**32,908.70**	**34,159.23**	**35,457.28**	**152,301.14**
280 - Foreign Travel	0.00	4,000.00	4,000.00	4,000.00	4,000.00	16,000.00
290 - Domestic Travel	0.00	2,000.00	2,000.00	2,000.00	2,000.00	8,000.00
300 - PO Purchases	5,000.00	10,000.00	10,000.00	10,000.00	10,000.00	45,000.00
MSTC-LV	**5,000.00**	**16,000.00**	**16,000.00**	**16,000.00**	**16,000.00**	**69,000.00**
251 - Electric - Distributed	346.98	608.72	631.85	655.86	680.78	2,924.19
OTH-EXEMPT	**346.98**	**608.72**	**631.85**	**655.86**	**680.78**	**2,924.19**
700 - Organizational Burden	2,277.07	3,994.70	4,146.50	4,304.06	4,467.62	19,189.95
DEPT-CHRGS	**2,277.07**	**3,994.70**	**4,146.50**	**4,304.06**	**4,467.62**	**19,189.95**
705 - LDRD Burden	1,282.45	2,632.93	2,700.76	2,771.16	2,844.25	12,231.55
710 - G&A Burden	2,116.14	4,344.50	4,456.42	4,572.59	4,693.18	20,182.83
720 - Common Support	7,027.77	14,428.34	14,800.03	15,185.85	15,586.32	67,028.31
725 - IGPP Burden	641.23	1,469.11	1,503.02	1,385.58	1,422.12	6,421.06
745 - Procurement	300.00	960.00	960.00	960.00	960.00	4,140.00
LABWIDE-OH	**11,367.59**	**23,834.88**	**24,420.23**	**24,875.18**	**25,505.87**	**110,003.75**
050 - SCI3 - 17504 - RESCIA ,SERGIO	0.10	0.10	0.10	0.10	0.10	0.50
050 - TECH4 - 15299 - HOFFMANN ,AUGUST	0.00	0.10	0.10	0.10	0.10	0.40
TOTAL PERSONNEL	**0.10**	**0.20**	**0.20**	**0.20**	**0.20**	**0.90**

Budget Plan Dept Code: PO
Revision Id: CURRENT REVISION 1
Budget Plan Id: BNL WBS 6.3.3

Description	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	TOTAL 5 YEARS
COST PLAN	**35,799.50**	**89,320.29**	**92,048.64**	**94,668.17**	**95,998.58**	**407,835.18**
050 - Base Salary	14,506.05	42,591.80	44,264.53	45,946.58	47,692.56	195,001.52
SALARY	**14,506.05**	**42,591.80**	**44,264.53**	**45,946.58**	**47,692.56**	**195,001.52**
290 - Domestic Travel	0.00	3,000.00	3,000.00	3,000.00	2,000.00	11,000.00
300 - PO Purchases	8,000.00	10,000.00	10,000.00	10,000.00	10,000.00	48,000.00
MSTC-LV	**8,000.00**	**13,000.00**	**13,000.00**	**13,000.00**	**12,000.00**	**59,000.00**
251 - Electric - Distributed	278.52	817.76	849.88	882.17	915.70	3,744.03
OTH-EXEMPT	**278.52**	**817.76**	**849.88**	**882.17**	**915.70**	**3,744.03**
700 - Organizational Burden	1,827.76	5,366.57	5,577.33	5,789.27	6,009.26	24,570.19
DEPT-CHRGS	**1,827.76**	**5,366.57**	**5,577.33**	**5,789.27**	**6,009.26**	**24,570.19**
705 - LDRD Burden	1,240.69	3,086.92	3,181.09	3,275.79	3,321.09	14,105.58
710 - G&A Burden	2,047.21	5,093.63	5,249.02	5,405.29	5,480.04	23,275.19
720 - Common Support	6,798.93	16,916.14	17,432.21	17,951.16	18,199.39	77,297.83
725 - IGPP Burden	620.35	1,667.48	1,714.57	1,637.90	1,660.55	7,300.85
745 - Procurement	480.00	780.00	780.00	780.00	720.00	3,540.00
LABWIDE-OH	**11,187.18**	**27,544.17**	**28,356.89**	**29,050.14**	**29,381.07**	**125,519.45**
050 - PROF3 - 22393 - CHEN ,HUCHENG	0.05	0.10	0.10	0.10	0.10	0.45
050 - PROF4 - 14676 - KIERSTEAD ,JAMES	0.05	0.10	0.10	0.10	0.10	0.45
050 - TECH4 - 15299 - HOFFMANN ,AUGUST	0.00	0.10	0.10	0.10	0.10	0.40
TOTAL PERSONNEL	**0.10**	**0.30**	**0.30**	**0.30**	**0.30**	**1.30**

Budget Plan Dept Code: PO
Revision Id: CURRENT REVISION 1
Budget Plan Id: BNL WBS 6.3.5

Description	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	5 YEAR TOTAL
COST PLAN	**92,821.87**	**227,081.09**	**240,617.88**	**246,705.34**	**263,645.85**	**1,070,872.03**
050 - Base Salary	32,720.68	94,567.60	98,215.41	101,947.60	105,821.61	433,272.90
SALARY	**32,720.68**	**94,567.60**	**98,215.41**	**101,947.60**	**105,821.61**	**433,272.90**
280 - Foreign Travel	6,000.00	8,000.00	8,000.00	8,000.00	10,000.00	40,000.00
300 - PO Purchases	20,000.00	40,000.00	45,000.00	45,000.00	50,000.00	200,000.00
MSTC-LV	**26,000.00**	**48,000.00**	**53,000.00**	**53,000.00**	**60,000.00**	**240,000.00**
251 - Electric - Distributed	628.24	1,815.70	1,885.74	1,957.39	2,031.77	8,318.84
OTH-EXEMPT	**628.24**	**1,815.70**	**1,885.74**	**1,957.39**	**2,031.77**	**8,318.84**
700 - Organizational Burden	4,122.81	11,915.52	12,375.14	12,845.40	13,333.52	54,592.39
DEPT-CHRGS	**4,122.81**	**11,915.52**	**12,375.14**	**12,845.40**	**13,333.52**	**54,592.39**
705 - LDRD Burden	3,220.17	7,868.16	8,338.53	8,548.65	9,137.76	37,113.27
710 - G&A Burden	5,313.45	12,982.93	13,759.06	14,105.78	15,077.83	61,239.05
720 - Common Support	17,646.43	43,117.12	45,694.74	46,846.19	50,074.48	203,378.96
725 - IGPP Burden	1,610.09	3,934.08	4,169.26	4,274.32	4,568.88	18,556.63
745 - Procurement	1,560.00	2,880.00	3,180.00	3,180.00	3,600.00	14,400.00
LABWIDE-OH	**29,350.14**	**70,782.29**	**75,141.59**	**76,954.94**	**82,458.95**	**334,687.91**
050 - PROF3 - 22393 - CHEN ,HUCHENG	0.05	0.10	0.10	0.10	0.10	0.45
050 - PROF4 - 20680 - MEAD ,JOSEPH	0.10	0.30	0.30	0.30	0.30	1.30
050 - TECH2 - 19038 - BICHONEAU ,PIERROT	0.10	0.20	0.20	0.20	0.20	0.90
050 - TECH4 - 22179 - ACKLEY ,KIM	0.00	0.10	0.10	0.10	0.10	0.40
TOTAL PERSONNEL	**0.25**	**0.70**	**0.70**	**0.70**	**0.70**	**3.05**

Budget Plan Dept Code: PO
Revision Id: CURRENT REVISION 1
Budget Plan Id: BNL WBS 6.3.6

Description	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	5 YEAR TOTAL
COST PLAN	**80,143.13**	**195,040.56**	**202,200.22**	**195,860.11**	**154,782.73**	**828,026.75**
050 - Base Salary	24,947.42	66,551.00	69,079.93	71,704.97	74,429.76	306,713.08
SALARY	**24,947.42**	**66,551.00**	**69,079.93**	**71,704.97**	**74,429.76**	**306,713.08**
280 - Foreign Travel	4,000.00	8,000.00	8,000.00	8,000.00	10,000.00	38,000.00
290 - Domestic Travel	2,000.00	4,000.00	6,000.00	4,000.00	2,000.00	18,000.00
300 - PO Purchases	20,000.00	45,000.00	45,000.00	40,000.00	10,000.00	160,000.00
MSTC-LV	**26,000.00**	**57,000.00**	**59,000.00**	**52,000.00**	**22,000.00**	**216,000.00**
251 - Electric - Distributed	478.99	1,277.78	1,326.33	1,376.74	1,429.05	5,888.89
OTH-EXEMPT	**478.99**	**1,277.78**	**1,326.33**	**1,376.74**	**1,429.05**	**5,888.89**
700 - Organizational Burden	3,143.37	8,385.43	8,704.07	9,034.83	9,378.15	38,645.85
DEPT-CHRGS	**3,143.37**	**8,385.43**	**8,704.07**	**9,034.83**	**9,378.15**	**38,645.85**
705 - LDRD Burden	2,782.54	6,767.82	7,016.20	6,792.99	5,356.40	28,715.95
710 - G&A Burden	4,591.32	11,167.24	11,577.08	11,208.79	8,838.42	47,382.85
720 - Common Support	15,248.22	37,087.39	38,448.50	37,225.30	29,352.75	157,362.16
725 - IGPP Burden	1,391.27	3,383.91	3,508.10	3,396.50	2,678.20	14,357.98
745 - Procurement	1,560.00	3,420.00	3,540.00	3,120.00	1,320.00	12,960.00
LABWIDE-OH	**25,573.35**	**61,826.36**	**64,089.88**	**61,743.58**	**47,545.77**	**260,778.94**
050 - PROF3 - 22393 - CHEN ,HUCHENG	0.05	0.20	0.20	0.20	0.20	0.85
050 - PROF4 - 20680 - MEAD ,JOSEPH	0.05	0.10	0.10	0.10	0.10	0.45
050 - TECH2 - 19038 - BICHONEAU ,PIERROT	0.10	0.10	0.10	0.10	0.10	0.50
050 - TECH4 - 20657 - WOLNIEWICZ ,KEVIN	0.00	0.10	0.10	0.10	0.10	0.40
TOTAL PERSONNEL	**0.20**	**0.50**	**0.50**	**0.50**	**0.50**	**2.20**

Table D-3: BNL Calorimeter Electronics Summary Budget

<u>University of Chicago</u>: Statement of Work and Budgets

The University of Chicago works on five WBS categories in the development of front-end electronics for the Tile calorimeter. The UofC group co-designed the current ATLAS Tile Calorimeter front-end electronics and therefore has an excellent knowledge of calorimeter properties and the DAQ system. Our group has been designing a discrete-component version of the “3-in-1” card that accepts the PMT signals, filters and amplifies, and performs charge injection and Cs source integration; this constitutes WBS 6.3.2. We have built a prototype card with commercial off-the-shelf components, and propose to perform radiations tests on this prototype at sources of ionizing radiation, protons, and neutrons.

For WBS 6.3.3 we propose to design a radiation test PCB to qualify commercial ADC alternatives. We also will design a high-bandwidth card to serialize the ADC output and send it to an FPGA. Under WBA 6.3.1 we design the overall Main Board architecture for the ADC/FPGA system, incorporating system redundancy and error correction. The FPGA system must also be radiation qualified either on a prototype Main Board or a dedicated FPGA test board. An important qualification for SEU will be to test a configuration of triple-FPGA majority logic together with CERN-originated bit error correction code.

WBS 6.3.4 sees the incorporation of fiberoptic drivers into the Main Board system and radiation qualification of a Main Board prototype. We have obtained state of the art 12-fiber drivers from Reflex photonics and Avago, and we propose to design a high-bandwidth daughter-card for the Main Board. The daughter card, on a Rogers substrate, would carry the high-bandwidth components.

With the aforementioned fiberoptic data link, all digitized signals can be sent off-detector for trigger processing. In WBS 6.3.6 we design an analog trigger component of the Main board to maintain backwards-compatibility with the current Tile and LAr systems. This is necessary if we are to install a demonstrator system in a portion of the calorimeter so that the digitized trigger information and latencies can be assessed by the Level-1 calorimeter trigger group during data-taking in 2018.

Budget Justification

The five activities described above can be achieved if we can continue at the level of effort invested in the first half of FY2011. This consisted of the advanced PCB design work by an electrical engineer (Fukun Tang) and additional consulting by the head of the Electronics Design Group at the Enrico Fermi institute; this constitutes 1.3 FTE at $100/hour, with no overhead charge. For prototype manufacture and to assist in the radiation tests we need an additional 25% FTE of technicians (no overhead, currently billed at $65/hour). M&S at the level of approximately $36k per year (again with no overhead) covers the cost of design software, diagnostic instrumentation, and prototype manufacture. Travel at the level of $10K per year (56% overhead) is necessary for US and international meetings of the upgrade design groups, and to travel to US sites to conduct radiation exposures. The first year FY11 is assumed to be an effective half-year in length and a 3% escalation factor is applied to each subsequent year.

University of Chicago Budget (AY$) for Collider Detector Program Proposal

WBS	Tasks & Resources	FY2011 FTE	FY2011 Funds Requested	FY2012 FTE	FY2012 Funds Requested	FY2013 FTE	FY2013 Funds Requested	FY2014 FTE	FY2014 Funds Requested	FY2015 FTE	FY2015 Funds Requested	Total FTE	Total Funds Requested
6.3.1	**Readout Architecture and System Integration**												
	Electrical Engineer	0.06	11,000	0.13	23,566	0.13	24,273	0.13	25,002	0.13	25,752	0.58	109,593
	Tech/student	0.01	1,430	0.03	2,946	0.03	2,946	0.03	3,034	0.03	3,125	0.11	13,481
	M&S		1,800		3,708		3,819		3,934		4,052		17,313
	Travel		500		1,000		1,000		1,000		1,000		4,500
	IDC		280		560		560		560		560		2,520
	Total	0.08	15,010	0.16	31,780	0.16	32,598	0.16	33,530	0.16	34,489	0.70	147,407
6.3.2	**Analog Signal Conditioning and Noise Optimization**												
	Electrical Engineer	0.16	27,500	0.33	58,916	0.33	60,683	0.33	62,504	0.33	64,379	1.46	273,983
	Tech/student	0.03	3,575	0.06	7,365	0.06	7,365	0.06	7,585	0.06	7,813	0.28	33,702
	M&S		4,500		9,270		9,548		9,835		10,130		43,282
	Travel		1,250		2,500		2,500		2,500		2,500		11,250
	IDC		700		1,400		1,400		1,400		1,400		6,300
	Total	0.19	37,525	0.39	79,451	0.39	81,496	0.39	83,824	0.39	86,222	1.74	368,517
6.3.3	**On Detector Digitization and Data Organization**												
	Electrical Engineer	0.19	33,000	0.39	70,699	0.39	72,820	0.39	75,005	0.39	77,255	1.75	328,779
	Tech/student	0.04	4,290	0.08	8,837	0.08	8,837	0.08	9,103	0.08	9,376	0.34	40,443
	M&S		5,400		11,124		11,458		11,801		12,155		51,939
	Travel		1,500		3,000		3,000		3,000		3,000		13,500
	IDC		840		1,680		1,680		1,680		1,680		7,560
	Total	0.23	45,030	0.47	95,341	0.47	97,795	0.47	100,589	0.47	103,466	2.09	442,221
6.3.4	**High Speed Optical Links and Trigger Input Solutions**												
	Electrical Engineer	0.16	27,500	0.33	58,916	0.33	60,683	0.33	62,504	0.33	64,379	1.46	273,983
	Tech/student	0.03	3,575	0.06	7,365	0.06	7,365	0.06	7,585	0.06	7,813	0.28	33,702
	M&S		4,500		9,270		9,548		9,835		10,130		43,282
	Travel		1,250		2,500		2,500		2,500		2,500		11,250
	IDC		700		1,400		1,400		1,400		1,400		6,300
	Total	0.19	37,525	0.39	79,451	0.39	81,496	0.39	83,824	0.39	86,222	1.74	368,517
6.3.6	**Calorimeter Trigger Interface Demonstrator**												
	Electrical Engineer	0.06	11,000	0.13	23,566	0.13	24,273	0.13	25,002	0.13	25,752	0.58	109,593
	Tech/student	0.01	1,430	0.03	2,946	0.03	2,946	0.03	3,034	0.03	3,125	0.11	13,481
	M&S		1,800		3,708		3,819		3,934		4,052		17,313
	Travel		500		1,000		1,000		1,000		1,000		4,500
	IDC		280		560		560		560		560		2,520
	Total	0.08	15,010	0.16	31,780	0.16	32,598	0.16	33,530	0.16	34,489	0.70	147,407
	Univ of Chicago Total	**0.75**	**150,100**	**1.55**	**317,802**	**1.55**	**325,984**	**1.55**	**335,296**	**1.55**	**344,887**	**6.95**	**1,474,069**

Table D-4: University of Chicago Calorimeter Electronics Summary Budget

<u>Columbia University/Nevis Lab</u>: Statement of Work and Budgets

Nevis will develop two ASICs: a fast, low power, radiation tolerant, 4-channel, 12-bit dynamic range ADC with internal gain selection to achieve 16-bit dynamic range for each channel, and a multiplexer chip that combines the (serialized) data from multiple ADCs, inserts additional control words, and serializes the data for transmission over high-speed (5-10 Gbps) links. In addition, Nevis will design and fabricate the front-end prototype board which integrates these components with the preamp/shapers and optical transmitters.

The funds requested cover the significant engineering and technical support needs for these projects: 1.5 FTE electrical engineer (J. Ban, B. Sippach and L. Zhang each at 0.5 FTE), 1.0 FTE electrical engineer intern (J. Kuppambatti, a student in the Columbia University Electrical Engineering department) and 1.0 FTE electrical technician (N. Bishop and M. Hwang each at 0.5 FTE). This team is well-suited to complete this project successfully: B. Sippach and J. Ban designed the radiation-tolerant analog pipeline chip and a number of digital chips used in ATLAS liquid Argon calorimeter readout, and designed its current front-end boards. B. Sippach, J. Ban and L. Zhang also designed the electronics boards for the D0 experiment's Level 1 calorimeter trigger, and implemented the algorithms and 2 Tbps dataflow logic in the FPGAs. J. Kuppambatti is a Ph.D. student in P. Kinget's group, which specializes in low voltage analog designs, including state-of-the-art ADC developments.

The engineers (and intern) are focused on the design and layout of the ASICs and design and programming of the corresponding test-boards, and the technicians handle the test-board fabrication and (in-house) assembly, as well as management of test equipment. The FTE needs have been evaluated based on experience with this project in the past three years.

In addition, funds are requested for a) fabrication of test-boards for the Nevis10 chip in FY2011 (a few were made but more are needed for radiation testing), b) fabrication of the Nevis12 chip (development of radiation-tolerant reference voltage circuit, scalable OTA, possibly calibration engine) and corresponding test-boards in FY2012, c) fabrication of the full ADC prototype and corresponding test-boards in FY2013, d) fabrication of the MUX prototype and corresponding test-boards in FY2014, and e) fabrication of the FEB2 demonstrator board, expected to be a pre-prototype, in FY2015.

Columbia University Budgets (AY$) for Collider Detector Program Proposal (Calorimeter Electronics)

		FY11		FY12		FY13		FY14		FY15		Total	
WBS	Tasks & Resources	FTE	Funds Requested	FTE	Funds Requeste d	FTE	Funds Requested	FTE	Funds Requeste d	FTE	Funds Requeste d	FTE	Funds Requested
6.3.1	**Readout Arch & System Integr**												
6.3.3	**On-detector digitization & data organization**												
	J.Ban, B.Sippach, L.Zhang (EE)	0.50	120,503	0.50	245,825	0.50	250,741	0.50	255,755	0.17	260,871	2.17	1,133,695
	N.Bishop, M.Hwang (ET)	0.50	37,475	0.50	76,448	0.50	77,977	0.50	79,536	0.08	81,126	2.08	352,562
	J.Kuppambatti (Intern)	0.50	15,600	1.00	31,824	1.00	32,460	1.00	33,109	1.00	33,771	4.50	146,764
	Total Salary & Fringe		173,578		354,097		361,178		368,400		375,768		1,633,021
	M&S (chips & testboards)		5,000		25,000		50,000		10,000		10,000		100,000
	Fees (Intern Tuition)		9,117		18,600		18,972		19,351		19,738		85,778
	Total Direct		187,695		397,697		430,150		397,751		405,506		1,818,799
	Base Subject to Indirect		31,398		64,051		65,332		66,638		67,971		295,390
	Indirect		13,693		27,933		28,492		29,061		29,642		128,821
	Total	**1.50**	**201,388**	**2.00**	**425,630**	**2.00**	**458,642**	**2.00**	**426,812**	**1.25**	**435,148**	**8.75**	**1,947,620**

Table D-5: Columbia University Calorimeter Electronics Summary Budget

Michigan State University: Statement of Work and Budgets

WBS 6.3.5. MSU will be collaborating with BNL and Arizona to develop a full speed prototype ROD. The research program will be broad and encompass Monte Carlo simulation studies, hardware prototyping, firmware and software development. Our anticipated annual research program follows.
2011: We will focus on definition of the interface between calorimeters and L1 Calorimeter trigger – data presentation and formats – in collaboration with L1Calorimeter trigger groups, BNL and Arizona. A common VHDL/FPGA development framework (to be used by all groups) will be defined.
Milestone: ROD - L1 Calorimeter trigger data format and data presentation proposal. A common VHDL/FPGA development framework proposal.
2012: We will focus on a hardware design study for high speed optical links using FPGA serial transceivers to be used in the rear transition module for optical transmission to L1 trigger.
Milestone: A high speed optical links test setup.
2013: We will focus on rear transition module firmware and test benches to test this firmware.
Milestone: Firmware prototype of the rear transition module.
2014: We will build a prototype of the rear transition module needed to send data to L1 trigger and software needed to test this module
Milestone: A prototype of the rear transition module
2015: Commissioning and test of the complete full speed prototype ROD consisting of the ATCA carrier board, four AMC modules, and a rear transition module.
Milestone: A test setup for the ROD prototype.

MSU Budgets (AY$) for Collider Detector R&D Program Proposal (Calorimeter Electronics)

		FY2011		FY2012		FY2013		FY2014		FY2015		Total	
WBS	Task & Resources	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested
6.3	**Calorimeter Electronics**												
6.3.5	**Data organization and processings**												
	Mike Nila-technician	0.15	10,000	0.30	20,000	0.30	20,000	0.30	20,000	0.30	20,000	1.35	90,000
	Yuri Ermoline -engineer	0.15	16,000	0.30	32,000	0.30	32,000	0.30	32,000	0.30	32,000	1.35	144,000
	MSU engineer	0.08	7,500	0.15	15,000	0.30	30,000	0.30	30,000	0.30	30,000	1.13	112,500
	undergrad student		10,000		10,000		10,000		10,000	0.00	10,000		50,000
	Materials&supplies		5,000		20,000		10,000		10,000	0.00	10,000		55,000
	Consultant services-Shooltz Solutions		5,000		10,000		10,000		10,000	0.00	10,000		45,000
	Travel		5,000		10,000		10,000		10,000	0.00	10,000		45,000
	Total Direct		58,500		117,000		122,000		122,000	0.00	122,000		541,500
	Indirect		16,000		30,000		30,000		30,000	0.00	30,000		136,000
	MSU Total	**0.38**	**74,500**	**0.75**	**147,000**	**0.90**	**152,000**	**0.90**	**152,000**	**0.90**	**152,000**	**3.83**	**677,500**

Table D-6: Michigan State University Calorimeter Electronics Summary Budget

University of Pennsylvania: Statement of Work and Budgets

Penn has participated in the front end electronics for high channel count, low cost per channel experiments for more than 30 years. During this time we have developed specialized test equipment, front end boards , backplanes with analog and digital signal routing and at least ten highly successful analog and digital ASICS. Many experiments have benefited both directly and indirectly from this work and each of the implementations has been successful with very little rework or redesign required. An example of the system level design is in the SNO analog trigger where the discriminated outputs of 10,000 PMT contribute over a 20 crate system to a single fast analog sum with an electronic threshold of single tube accuracy. Notably we have taken major responsibility for the design and development of:

E613 BNL, neutrino scattering experiment, in the mid to late 70's, E734 BNL neutrino neutral scattering experiment, ~1979-1984. Kamiokande II, 1984-90, CDF upgrade to the COT, CDF TOF system, SNO and ATLAS TRT. We are familiar with the system level requirements for high channel count experiments and have taken responsibility for all facets of the design in several neutrino detectors and most of the on and near detector electronics for the ATLAS TRT. The combined design experience at the EE level of Richard Van Berg (Instrumentation group leader), Mitch Newcomer (Analog and systems design expert) and Nandor Dressnadt (Analog and CAD design expert) sums to more than 90 years. Our Technical staff, includes: Walt Kononenko to help with testing and materials management; Godwin Mayers, responsible for PCB design, assembly, repair, FPGA programming, Lab View based test environments and training students to help with hand and automated assembly equipment ; Michael Reilly , responsible for procurement, repair, troubleshooting and equipment management.

WBS 6.3.1. Readout architecture and system integration: Richard Van Berg and Mitch Newcomer will draw on a long history of the development of system architecture for HEP experiments to help define the architecture of the upgraded front end electronics. As part of this effort we will help with the detailed design specification of the new Front end Electronics boards. With the help of Nandor Dressnandt we intend to help provide the layout of the analog front end and other parts of the board as required. Since most of the meetings concerning architecture will include detailed design issues concerning the analog front end electronics, we are requesting coverage for one trip to BNL per dedicated solely to the readout architecture.

WBS 6.3.2. Analog signal conditioning and noise optimization: Penn has a long history of providing low noise ASICs for both PMT and ionization chamber readout. These ASICs have been used in SNO, CDF, and ATLAS as primary targets but have also found their way into HERAb, ZEUS, GSI R3B and many other experiments. Mitch Newcomer, in consultation with Sergio Rescia at BNL, will lead the design effort that has already begun to provide a new Preamp and Shaper ASIC. We are requesting coverage for one month (12.5%) of his time per year. In the remainder of FY11 through FY13. He will take responsibility for the migration of the design already submitted in IBM's 8WL process to be compatible with the IHP process and subsequent processes if required. He will also specify the design of test stands, help to come up with calibration techniques, perform detailed measurements on the fabricated designs and report the results at meetings and conferences. During this time Nandor Dressnandt, will take primary responsibility for the implementation of the schematic in the ASIC process and for assuring the fidelity of the signal processing over the full process ranges. We are asking for coverage of two months per year (16.67%) of his time. We expect to be ready to submit a preamp design with one or more variants in the IHP process by summer FY11 at an estimated cost of $20,000 (Budgetary quote) as part of a multi-project run in the IHP process. We are adding $400 for packaging of the bare die, an estimate based on past experience. We request another $500 for materials related to the test board for the ASIC. To the extent that we find the IHP process suitable for the upgraded LAr detector we will submit a second design in (FY12) with a near final design of the preamp and one or more variations of the shaper optimizing power and signal processing robustness in different ways. Since this design will take additional area and we will want >100pcs to satisfy prototyping needs we estimate that this MPW run will cost at least $24000. We add $1000 in the budget to cover the materials cost for developing the test board which we assume here is a multi-purpose PCB. Assuming a successful design it is likely that it will serve the FEB prototyping needs for at least two years. In what remains of FY13, FY14 the majority of the effort will be in the implementation of high channel count designs on PCBs. We request $1000 for each remaining year to cover fractional costs of board prototyping that will be shared with other collaborators, depending on the prototype board form factor. Mitch and Nandor will work together to specify appropriate high density ASIC packaging and perform the related PCB layout and test prototype designs. It is yet to be determined if the final form factor will be daughter boards or direct implementation on the FEB. In the time that may remain in FY15 we hope to design calibration and test procedures to ensure that ASICs can be quickly characterized with a set of parametric measurements that assure uniform performance when assembled on boards. This work can easily be propagated through to the completed multi-channel daughter boards that we envision currently being used on the upgrade FEB design. We request an additional $500 for materials to cover this effort.

Technical help: We are requesting a moderate amount of technician coverage, 1 month per year (8.33%) each for Walter Kononenko, Godwin Mayers and Mike Reilly for the duration of the project.

Univ of Penn. Budget (AY$) for Collider Detector R&D Program Proposal (Calor. Electronics)

		FY2011		FY2012		FY2013		FY2014		FY2015		Total	
WBS	Task & Resources	FTE	Cost	FTE	Cost	FTE	Cost	FTE	Cost	FTE	Cost	FTE	Cost
6.3.1	**Readout Arch & System Integr**												
	Labor	-	-	-	-	-	-	-	-	-	-	-	-
	Fringe Benefits		-		-		-		-		-	-	-
	Travel		400.00		400.00		400.00		400.00		400.00	-	2,000.00
	M&S		-		-		-		-		-	-	-
	Total Direct	-	400.00	-	400.00	-	400.00	-	400.00	-	400.00	-	2,000.00
	Total Indirect		240.00		240.00		240.00		240.00		240.00	-	1,200.00
	Subtotal	-	640.00	-	640.00	-	640.00	-	640.00	-	640.00	-	3,200.00
6.3.2	**Analog signal conditioning & noise optimization**												
	senior instrumentation specialist, designer, technicians and students	0.37	24,044	0.54	46,452	0.54	47,831	0.54	49,251	0.54	50,714	2.54	218,292
	Fringe Benefits		7,324		14,248		14,674		15,112		15,564	-	66,922
	Travel		400		1,900		1,900		1,900		1,900	-	8,000
	M&S		20,900		25,000		1,000		1,000		1,500	-	49,400
	Total Direct	0.37	52,668	0.54	87,600	0.54	65,405	0.54	67,263	0.54	69,678	2.54	342,614
	Total Indirect		19,061		37,560		38,643		39,758		40,907	-	175,929
	Subtotal	0.37	71,729	0.54	125,160	0.54	104,048	0.54	107,021	0.54	110,585	2.54	518,543
	U of Penn Total	**0.37**	**72,369**	**0.54**	**125,800**	**0.54**	**104,688**	**0.54**	**107,661**	**0.54**	**111,225**	**2.54**	**521,743**

Table D-7: Pennsylvania Calorimeter Electronics Summary Budget

Southern Methodist University: Statement of Work and Budgets

WBS 6.3.1. Readout architecture and system integration: We will work with groups responsible for the front- and back-end electronics to specify the readout architecture, define system integration and testing procedures, and conduct system integration tests. The optical link system comprises the transmitting side ASICs (the MUX, the serializer, the laser driver and control logics), electrical-to-optical converters (the OTx, including its mechanical packaging), radiation resistant fiber and connectors, and the receiving side optical-to-electrical converters (the ORx), the de-serializer and the interface to downstream electronics on the ROD board. We will provide system level specification for optical links operating in radiation environments, and define evaluation procedures to assure system level reliability. This part of the work is in collaboration with groups that develop a generic optical link (a joint proposal from US-ATLAS and

CMS) to answer the call for data bandwidth needs of 100 Gbps per front-end board. In that collaboration we also identify radiation tolerant fibers, optical interfaces (OTx, ORx and their mechanical packaging), and work on components and systems of the receiving side of the link. The development of the radiation tolerant ASICs (some of them may be system specific such as the MUX) for the transmitting side of the link is in this proposal and listed in 6.3.4.

WBS 6.3.4. High speed optical links: In the optical link R&D work subcontracted from BNL, SMU will continue the LOC ASICs development, prototyping and testing. We will first concentrate on the serializer ASIC development. The ASIC to interface the serializer to the ADC, called the MUX, will be first studied in an FPGA, and then translated into an ASIC. Whether we integrate the MUX and the serializer into one chip package will be studied at the final ASIC prototyping iteration. We will also investigate chip packaging options for 10 Gbps signal transmission. We plan to irradiate COTS serializers and laser diode drivers (LDDs) in parallel with the ASIC development. This is especially important to identify radiation tolerant 10 Gbps LDDs for the optical interface development. If we cannot find radiation tolerant COTS LDDs, we will develop ASIC LDDs using the same technology as the LOC serializer. We have identified radiation tolerant fibers, and some of the link back-end components in the Versatile Link project. For the de-serializer we plan to use SerDes embedded FPGAs and will follow developments in industry and gain experience of using these complex programmable chips. These activities are in the proposal to develop a generic optical link of 100 Gbps per detector front-end board, in collaboration with the Fermi Lab and other institutions in US-ATLAS and CMS. At the system level we are working on a system specification with collaborators in the whole readout chain (FEB, ROD, etc). The component work and system specification will lead us to a link demonstrator development for production readiness review in 2016.

To accomplish the above work, each year we need 1.5 FTE at ASIC design and system engineer level (they also function as hardware/firmware/software engineers depending the work they conduct at different phase of the project), and 0.5 FTE at electrical technician level to support all the engineering work. We request support in M&S for ASIC prototyping (one MWP run of the GC process costs $40k at Peregrine), packaging option studies, and component testing (including irradiation tests with the 200 MeV proton beam at IUCF which costs about $650/hr, 12 hr minimum for each test). Support to travel for irradiation tests, and necessary collaboration/technical meetings is also needed.

SMU Budget (AY$) for Collider Detector R&D Program Proposal (Calor. Electronics)

WBS	Task & Resources	FY2011 FTE	FY2011 Funds Requested	FY2012 FTE	FY2012 Funds Requested	FY2013 FTE	FY2013 Funds Requested	FY2014 FTE	FY2014 Funds Requested	FY2015 FTE	FY2015 Funds Requested	Total FTE	Total Funds Requested
6.3.1	**Readout Architecture & System Integr**												
6.3.4	**High Speed Optical Links**												
	D. Gong (EE)	0.50	32,500	1.00	66,950	1.00	68,959	1.00	71,027	1.00	73,158	4.50	312,594
	TBD (EE)	0.25	16,250	0.50	33,475	0.50	34,479	0.50	35,514	0.50	36,579	2.25	156,297
	K. Liu (ET)	0.25	8,750	0.50	18,025	0.50	18,566	0.50	19,123	0.50	19,696	2.25	84,160
	Total Salary & Fringe		73,600		151,616		156,164		160,849		165,675		707,904
	Travel		10,000		10,000		10,000		10,000		10,000		50,000
	M&S (ASIC proto & test)		60,000		60,000		60,000		80,000		40,000		300,000
	Total Direct		143,600		221,616		226,164		250,850		215,675		1,057,905
	Total Indirect		65,338		100,835		102,905		114,136		98,132	-	481,346
	SMU Calor Electronics Total	**1.00**	**208,938**	**2.00**	**322,451**	**2.00**	**329,069**	**2.00**	**364,986**	**2.00**	**313,807**	**9.00**	**1,539,251**

Table D-8: SMU Calorimeter Electronics Summary Budget

Stony Brook University: Statement of Work and Budgets

WBS 6.3.5. Data organization and processing for presentation to the DAQ system: We propose research and development of high-bandwidth data receivers, data routing hardware and digital processing hardware and algorithms for calorimeter read out with collaborators at BNL, Arizona. Bandwidths of 100 Gbps are needed, and we propose to develop and test high-channel count receiver digital electrons with routing and data organization matched to this bandwidth using FPGA chips with dedicated communications protocols. This includes development of firmware needed to implement data manipulation for interfacing to collider experiment's DAQ and read out systems. We also propose simulation studies to develop algorithms to process the data for trigger-related and global event calculations in real time and implementation of these algorithms in upgraded RDB hardware with our BNL and Arizona collaborators. The goal of FY2011-2013 is to design and develop firmware for an AMC format RDB module running at 12x10Gbps with close collaboration with BNL, each AMC module will process data from four front end boards. In FY2014-2015, we will work with BNL to design and test a RDB carrier board which will house four AMC RDB modules.

We request partial support for electrical engineering by the Stony Brook departmental shop services. The chief engineer, Charles Pancake, has related experience through work on the DZero Silicon Track Trigger digital signal processing hardware and on the recent PHENIX optical read out and data formatting FEB upgrades. The support request is 0.3 FTE in FY11 at the start of our involvement, and 0.6 FTE for FY12 and FY13 for the duration of this proposal for board design and firmware debugging, we also request 0.6 FTE for FY14 and FY15 for the RDB carrier board design and testing. We also request travel for one trip to CERN in each year from FY12 to FY15.

Stony Brook University Budget (AY$) for Collider Detector R&D Program Proposal

			FY2011		FY2012		FY2013		FY2014		FY2015		Total	
WBS	Task & Resources	Name	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested	FTE	Funds Requested
6.3.5	**Data Organization & processing for presentatin to the DAQ system**													
	Engineers 1	C. Pancake	0.30	30,600	0.60	61,200	0.60	61,200	0.60	61,200	0.60	61,200	2.70	275,400
	Materials&supplies		-	-	-	-	-	-	-	-	-	-	-	-
	Consultant services		-	-	-	-	-	-	-	-	-	-	-	-
	Travel (to CERN)		-	-	-	5,000	-	5,000	-	5,000	-	-	-	15,000
	Total Direct		0.30	30,600	0.60	66,200	0.60	66,200	0.60	66,200	0.60	61,200	2.70	290,400
	Indirect			10,328		22,343		22,343		22,343		20,655		98,010
	SBU Total		**0.30**	**40,928**	**0.60**	**88,543**	**0.60**	**88,543**	**0.60**	**88,543**	**0.60**	**81,855**	**2.70**	**388,410**

Table D-9: Stony Brook University Calorimeter Electronics Summary Budget

Appendix E. Background Information on Prior Developments for Stave Structures (WBS 6.2)

Stave structures for precision tracking have been an active area of research over the past few years. In this appendix we list some of the recent developments which form a basis for the work proposed here. These developments have been carried out within an ongoing international collaboration. Some of this work has been performed by non-US collaborators.

Mechanical aspects of pixel staves: Pixel staves are a demanding application due to the thermal performance and radiation tolerance required. In addition, pixel staves must fit into a rather closely packed configuration. Various prototypical objects have been constructed and tested thermally and mechanically, including with CO_2 cooling (see **Figure E-1**). Thermal prototypes have been instrumented for readout and also imaged in the IR. These prototypes have included a variety of core and facing materials and have also been compared to detailed thermal and mechanical simulations, and analyses. A key, and ongoing aspect, has been to develop models which properly include the complex material properties of foams and composites. Extensive thermal cycling and irradiation of a few structures up to 1 GRad have been done. Mechanical assembly of structures with embedded electrical cables has be studied as well. Small prototypes of non-planar (bent) structures (as an alternative to discs) have been made and concepts for disks have been developed but not fabricated.

Mechanical aspects of silicon strip staves and petals: Silicon strip staves must be stable and conform to geometric tolerances over long distances. They must also be (eventually) fabricated in relatively large numbers. The structure and fabrication of these staves has been addressed through a program of "stavelet" (short 1/3 length) studies (see **Figure E-2**). Stavelets have been used for thermal and fabrication studies as well as for electrical measurements. A number of longer, 1.2 meter, thermo-mechanical staves have been built and instrumented as well (see **Figure E-3**). Initially it was assumed that the stave needed to be very stiff, so as not to sag if supported only at the two extreme ends. More recently, a mechanical optimization has led to a concept where the stave is less stiff (less facing material) but is supported at some 5-6 points on a thin barrel structure. A barrel is well optimized for radial stiffness (vs. material) relative to a beam (stave). Furthermore, many (barrel) staves will be located off the 12(6) o'clock positions and therefore don't need to be very stiff relative to the gravitational forces anyway. Work has been done to study different mounting and alignment mechanisms to fix the stave on a barrel structure (see **Figure E-4**). A considerable amount of work has also been done to study the stave fabrication process and in particular to look at the types, use, application, and amounts of adhesives needed in the build. For use in the forward direction the stave generalizes to a tapered structure referred to as a "petal". A number of petal prototypes have also be fabricated and tested for mechanical performance (see **Figure E-5**). Work has also focused on QA and measurement methods used to characterize staves and petals mechanically and thermally. An environmental chamber and precision surface profiling system has been built and is in use (see **Figure E-6**). The kapton-copper bus cable has to be laminated on the stave surface. Co-curing is a process by which the cable and carbon fiber sheets are cured together. Such a process may lead to a simplified fabrication, less material, and improved thermal performance. Co-cure processes have been worked out and tested and a number of co-cured staves have been fabricated (see **Figure E-7**). Some of these have been used in subsequent electrical studies.

Stave electrical studies: A number of prototype modules, stavelets, and related components have been fabricated and tested to date. These should be considered as elements of the 1st generation electrical stave described in the proposal as part of the 2012 testing program. The stave module consists of a sensor (approx 10 x 10 cm^2) divided into four 2.5 cm strip sections. Each section has 1280 strips. The stave is read out by two hybrid circuits each containing two rows of 10 readout chips. The readout chip is called ABCN and is based upon a basic high luminosity LHC specification. The ABCN has been designed, fabricated, and probed in sufficient quantities to support the 1st generation stave program. A hybrid has been developed and fabricated in quantity. The hybrid was built in a panelized process which allows for efficient manufacture but also for bulk assembly, wirebonding, and test (see **Figure E-8**). A set of tools have been developed for precision assembly of sensors and hybrids into modules. All these fabrication aspects have been done with an eventual large scale manufacturing, assembly, and test procedure in mind. Modules have been tested in isolation and also mounted upon a 4-module stavelet (see **Figure E-9**). Noise measurements are at or near expectations. Since a module contains two hybrids and four effective readout segments, there is subtlety in the local ground and bypass configuration choice. A considerable amount of testing and analysis has been required in order to optimize the noise performance due to these aspects. The stavelets which are under study are biased with either serial powering or DC-DC conversion. A comparison of these schemes is a key and ongoing research area. The staves utilize a kapton-copper bus cable to service all the modules. A variety of these have been fabricated and tested.

DAQ and interfacing: Testing of stavelets, staves, and petals requires a multi-channel control and acquisition system. A 1st generation high speed multi-channel input/output (HSIO) system has been designed and fabricated (see **Figure E-10**). It is based upon a large FPGA which can simultaneously control and parse data from up to 48 parallel data streams. The project includes also a considerable software and firmware development. A number of systems are in use already. Auxiliary components have been developed to work in concert with HSIO including custom interface, powering, and end-of-stave boards. In order to operate a stave efficiently and with minimal cabling material, clock and control should be distributed in a multi-drop configuration. In a serial powered system, as well, each node of the system is at a different potential. In this case the multi-drop system is also AC coupled. Such large AC coupled multi-drop systems have been studied and operated successfully in this recent research phase. In order to address numerous modules on a stave or petal, a prototype interface ASIC has been developed and tested. This ASIC was configured, in particular, to work within an AC coupled system. (The HCC chip referred to in WBS 6.2.3 is a more sophisticated version of this ASIC.) Considerable analysis has been made of this circuit and an automated test and characterization system has been built and used to prepare large numbers of die for stave scale system tests (see **Figure *E-11***). A large system of 24 interface ASICs has been operated successfully with the HSIO tools on the controlled impedance co-cured bus cable, and serial powering (see **Figure *E-12***).

Alternative powering: Modules and stavelets have been built and tested with both serial and DC-DC powering. Serial powering requires a shunt regulator and power transistor to handle excess current. Such circuits have been under study for several years, initially with COTS components. Up to 30 drops have been operated under serial power. The ABCN chip contains a local shunt and transistor. A custom serial powering chip (referred to as SPI) has also been developed. With all this, there are a number of optional implementations of serial powering depending upon how the shunt is configured and these custom designs have also been tested on modules. For serial powering, a control and bypass circuit has also been developed and tested (see **Figure *E-13***). The bypass can be controlled externally or sense a local fault condition and activate autonomously. A serial powering current limited supply has been designed, built, and utilized as part of this program. For DC-DC powering, a buck conversion circuit was developed at CERN as part of a generic DC-DC effort. This circuit has been packaged to the specifications of a stavelet application and mounted on modules (see **Figure *E-14***). Noise and other performance tests are in progress.

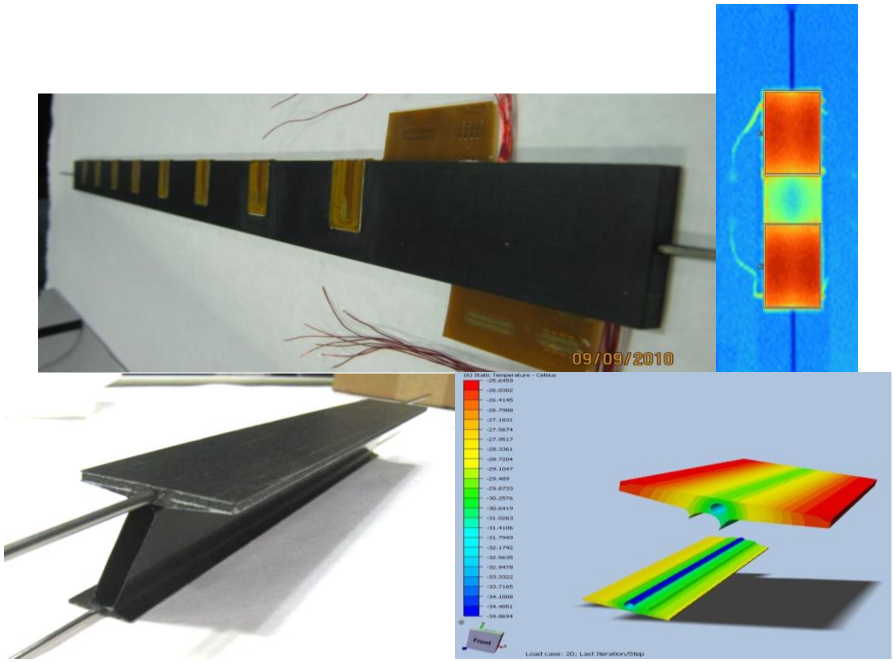


Figure E-1: Some examples of pixel mechanics. Top left is a long pixel stave outfitted for thermal and mechanical studies. An IR image of shorter prototype is shown at top right. Bottom left is a carbon composite I-beam pixel stave structure designed to deploy sensors at two radii within a single structure. The image at bottom right is a thermal simulation of the outer and inner radial faces of this structure.

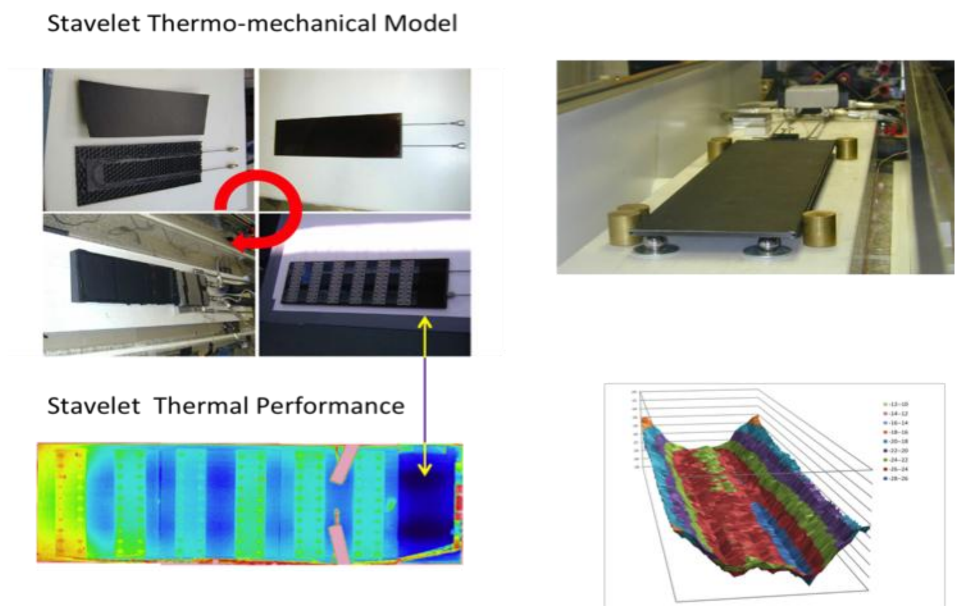


Figure E-2: Silicon strip stave mechanics. Upper left is part of the stave(let) fabrication sequence. This particular stavelet is instrumented for thermal studies with dummy loads. At lower left is a thermal image, the location of the cooling lines is visible. At lower right the temperature profile is shown as a vertical coordinate. At upper right a stavelet is on a kinematic mount for survey.

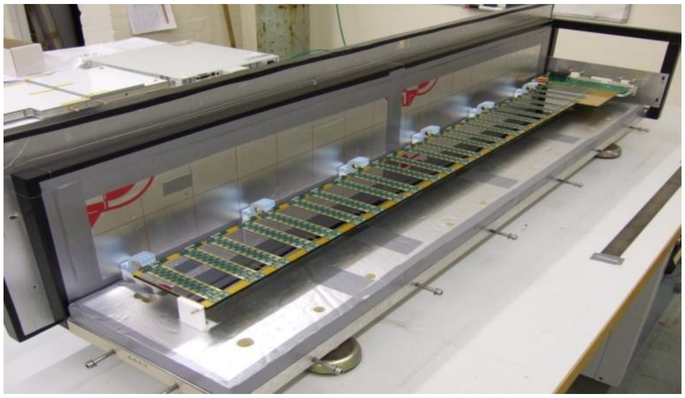


Figure E-3: A fully instrumented thermo-mechanical stave is being mounted in an environmental chamber

Figure E-4: Examples of mounting brackets developed to hold staves on support cylinders. A detail of a bracket is shown at top. At bottom, a series of brackets is holding a stave prototype (seen edge on).

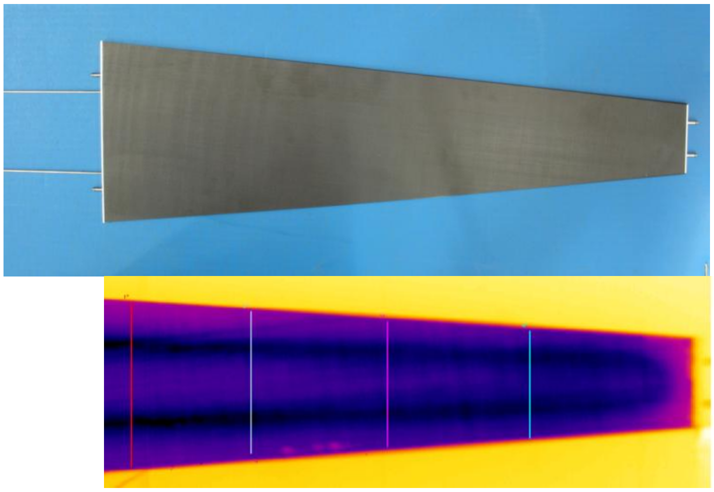


Figure E-5: A prototype petal core and thermal scan are shown.

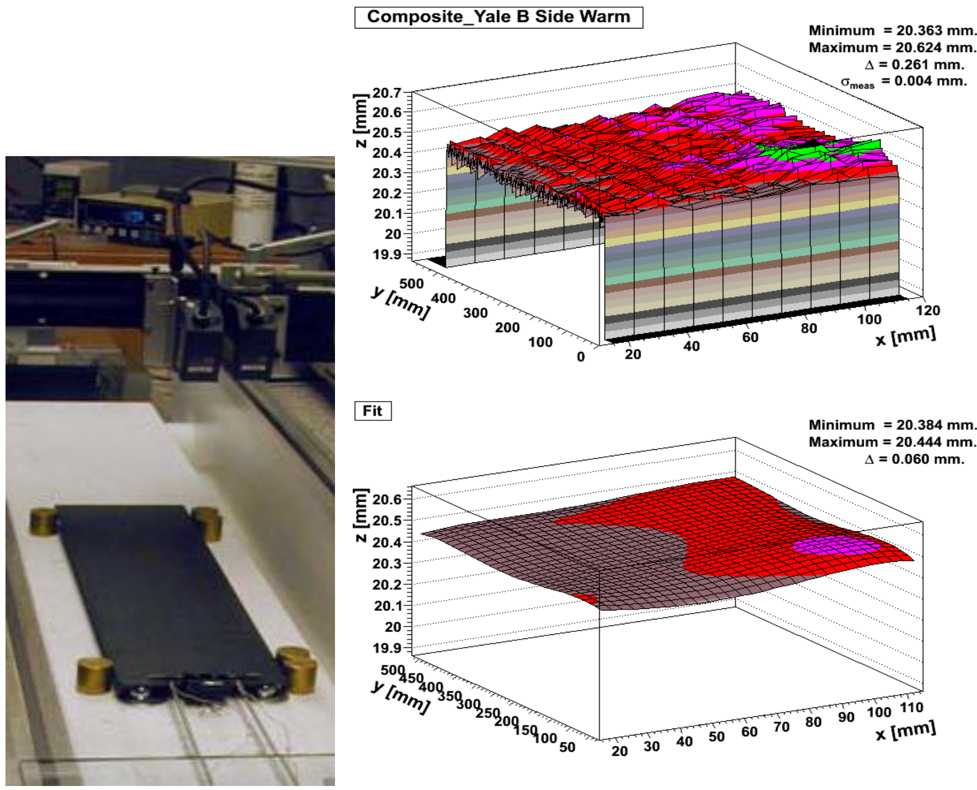


Figure E-6: A surface topology profiling system for staves is shown at left. The probe is a commercial laser triangulation sensor which has been integrated into a long scanning system to match the stave geometry. At upper right is a measurement from the profiling system, at lower right the data has been fit to a two-dimensional function.

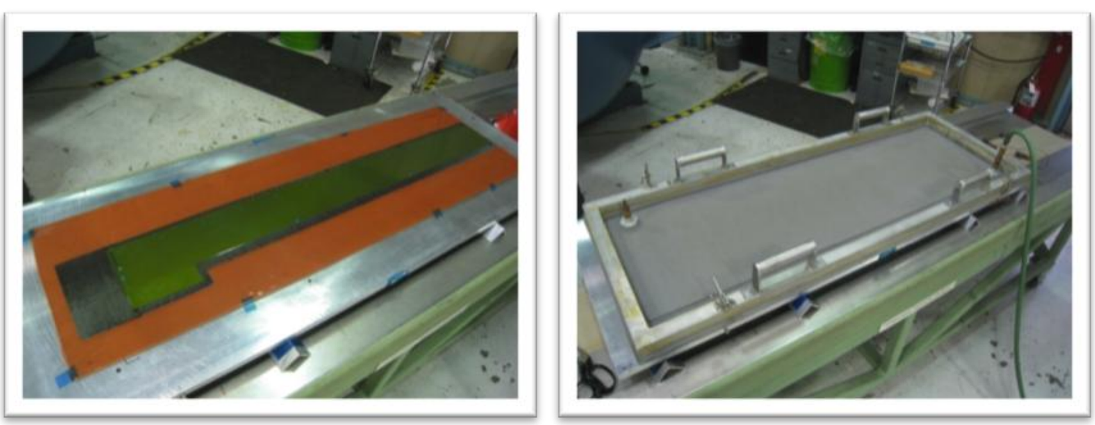


Figure E-7: Two steps in the stave facing/cable co-cure process. At left a cable has been placed on the uncured carbon fiber sheet. A right, the lay-up is being compacted under a vacuum frame.

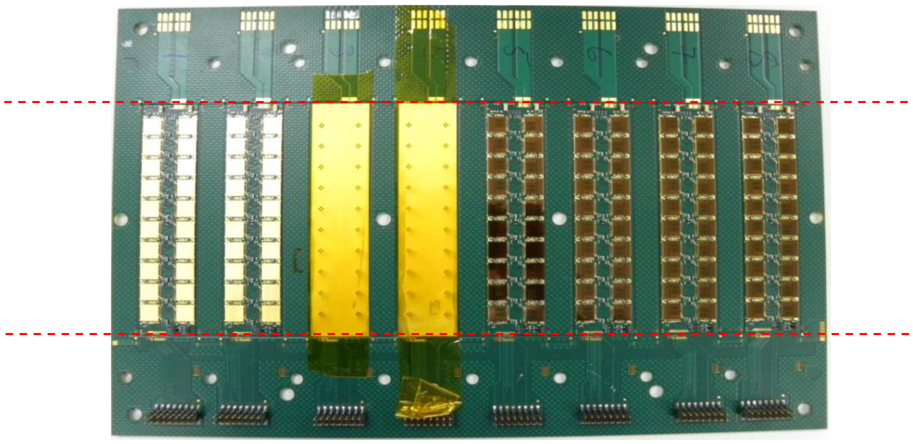


Figure E-8: A panel of eight hybrids in the process of assembly. After completion, the regions above (below) the upper (lower) dashed lines are trimmed away and discarded. Those regions contain temporary connectors used for testing and powering.

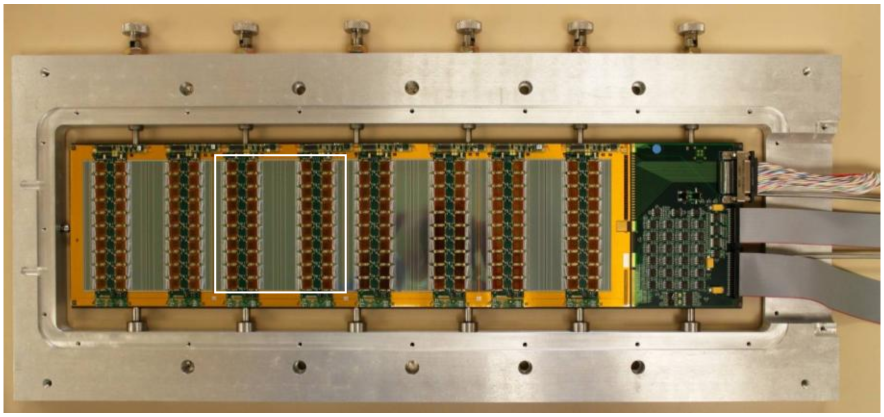


Figure E-9: A complete electrical stavelet containing four modules. One module is indicated with the white rectangular outline. At right is the end-of-stave card to interface to the DAQ. The stavelet is mounted in a temporary aluminum carrier/survey frame.

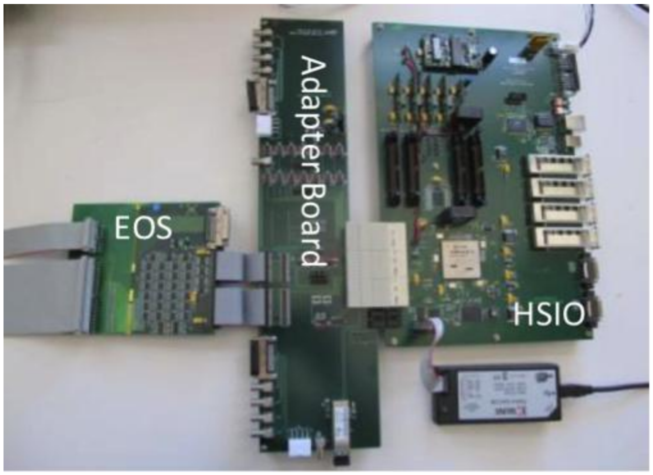


Figure E-10: Components of the HSIO control and DAQ system. The main board (right) contains an FPGA. The Adapter (or Interface) Board assigns all the FPGA resources to the appropriate lines servicing the stave.

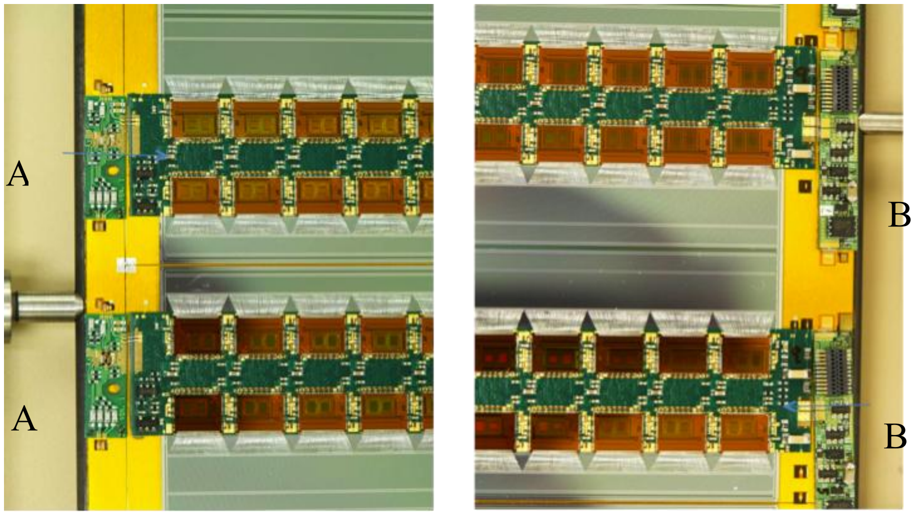


Figure E-11: Details of a module. At left the hybrid meets an adjacent local interface board (A) which contains a buffering chip (to become the HCC) which handles addressing and data multiplexing and buffers the multi-drop AC couple clock and command lines. Above and below each board can be seen wirebond pads to the bus cable underneath. At right the hybrid meets an adjacent power control board (B) which contains the serial current bypass circuitry and some of the optional shunt components.

Figure E-12: A stave with 24 addressing/buffer boards has been run together as a single, serial powered, AC coupled, multi-drop system.

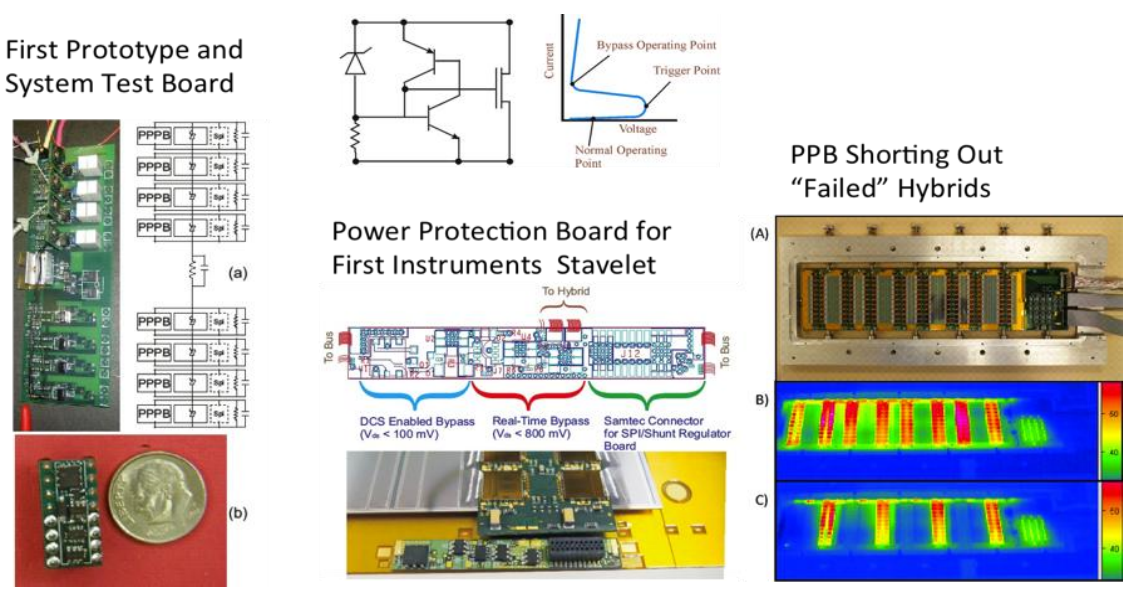


Figure E-13: Views of the various aspects of the autonomous and slow control serial current control system. At left top and bottom is a set of eight boards under initial test and evaluation. At center top is a schematic of the autonomous protection circuit which is placed across each hybrid. The circuit characteristic is shown as well. Should an open occur the circuit will trigger once the voltage across the hybrid exceeds a safety level. The physical implementation and module mounting is shown in the lower center images. At right is a stavelet with thermal images taken before and after the slow control bypass is activated on every other hybrid.

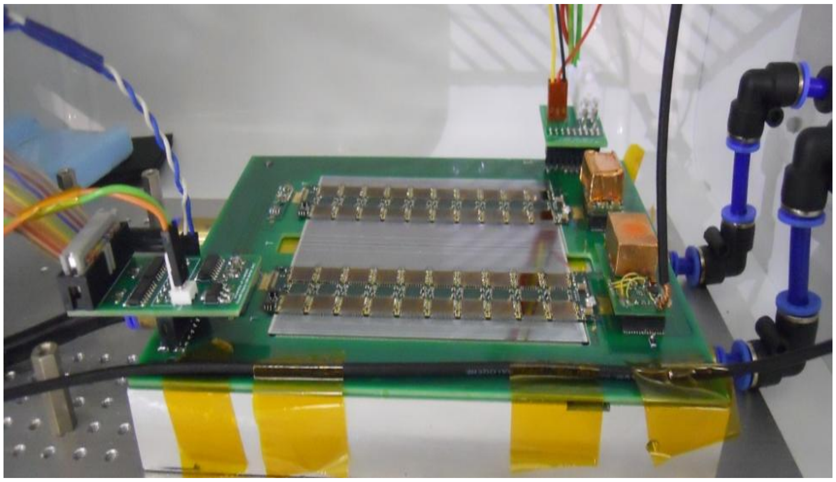


Figure E-14: A module configured for DC-DC powering. The copper boxes seen at right contain the buck converters which must be shielded due to the use of high frequency clocks.

References

[1] ATLAS Collaboration, "*ATLAS Insertable B-Layer Technical Design Report*," CERN-LHCC-2010-013, 2009.

[2] D. Arutinov et al., "*Digital architecture and interface of the new ATLAS pixel front-end IC for upgraded LHC luminosity*", IEEE Trans.Nucl.Sci. 56 (2009) 388-393.

[3] Pangaud P., "*A Tezzaron-Chartered 3D-IC electronic for SLHC/ATLAS pixels*", VIPS 2010 – Workshop on Vertically Integrated Pixel Sensors, Italy (2010) in2p3-00477362.

[4] See URL lansce.lanl.gov

[5] G. Casse et al., "*Response to minimum ionising particles of p-type substrate silicon microstrip detectors irradiated with neutrons to LHC upgrade doses*", NIM A581 (2007) p.318.
I. Mandic et al, "*Observation of full charge collection efficiency in heavily irradiated n+p strip detectors irradiated up to* 3×10^{15} *neq/cm*^{2}", NIM A 612 (2010) p. 474.

[6] P. Moreira et al., "*The GBT-SerDes ASIC prototype*", JINST 5, C11022 (2010).

[7] T. Akimoto et al., *The CDF Run IIb Silicon Detector: Design, preproduction, and performance* 2006. 23pp. Published in Nucl.Instrum.Meth.A556:459-481, 2006.

[8] The CMS Collaboration, CMS: *The Tracker Project Technical Design Report*, CERN-LHCC-98-06 (1998), Addendum to CMS Tracker TDR, CERN-LHCC-2000-016 (2000).

[9] The ATLAS Collaboration, G. Aad et al., "*The ATLAS Experiment at the CERN Large Hadron Collider*", JINST 3 (2008) S08003. http://www.iop.org/EJ/toc/1748-0221/3/08

[10] *WIT2010 Workshop on Intelligent Trackers,* Feb 2010 LBNL, Proceedings published online in JINST. http://iopscience.iop.org/1748-0221/focus/extra.proc7

[11] H. Wieman*, STAR PIXEL detector mechanical design* JINST 4 (2009) 05015. http://iopscience.iop.org/1748-0221/4/05/P05015/pdf/1748-0221_4_05_P05015.pdf

[12] L. Amaral et al., "*The versatile link, a common project for super-LHC*", JINST 4 P12003 (2009).

[13] T. Zimmerman, J. Hoff, "*The Design of a Charge-Integrating Modified-Floating Point ADC Chip*", IEEE J. Solid-State Circuits, vol. 39, no. 6, June, 2004, pp. 895-905.

[14] D. Gong et al., "*A 16:1 Serializer ASIC for Data Transmission at 5 Gbps",* TWEPP 2010 Aachen, Germany Sept. 22, 2010.

[15] T. Liu et al., "*A 4.9 GHz Low Power, Low Jitter, LC Phase Locked Loop* ", TWEPP 2010 Aachen, Germany Sept. 22, 2010.

Biographical Sketch: Ayana Tamu Arce

Education and training

B.S. (Physics) — Princeton University, 1998 (High Honors)
Thesis: "Sensitivity of the BELLE detector to CPT violation in the B system."

Ph.D (Physics) — Harvard University, March 2006
Dissertation: *First direct limit on the top quark lifetime at the Collider Detector at Fermilab.*

Postdoctoral fellowship (Physics) — Lawrence Berkeley Laboratory, 2006-2009

Research and Professional Experience

Professional positions

Research Assistant — **Harvard University**
Collider Detector at Fermilab (CDF) — 1999-2006

Chamberlain Postdoctoral Fellow — **Lawrence Berkeley Laboratory**
ATLAS Experiment at the Large Hadron Collider — 2006-2009

Assistant Professor of Physics — **Duke University**
ATLAS Experiment at the Large Hadron Collider — Jan. 2010-present

Publications

ATLAS Collaboration (F. Aad. *et al*). "Expected Performance of the ATLAS Experiment, Detector, Trigger and Physics." CERN. 1828p. 2009. (http://arxiv.org/abs/0901.0512v4)

CDF Collaboration (D. Acosta *et al*). "Measurement of the t anti-t production cross section in p anti-p collisions at $\sqrt{s} = 1.96$ TeV using lepton + jets events with secondary vertex b-tagging." Phys.Rev.D71: 052003. 2005. (http://prd.aps.org/abstract/PRD/v71/i5/e052003)

"CDF central outer tracker." T. Affolder *et al.*, Nucl. Instrum. Meth. A **526**, 249 (2004).

Selected recent presentations

"The ATLAS experiment: status and prospects" — October 2010
Invited, Southeastern Section of the American Physical Society (Baton Rouge)

"Prospects for New Physics at the LHC" — February 2010
Plenary, American Physical Society (Washington)

"The strong, the weak, and the Large Hadron Collider" — January 2010
Plenary, Conference for Undergraduate Women in Physics (Duke)

"Prospects for Top Physics at the LHC" — February 2009
Invited, Physics in the LHC Era (Aspen Winter Conference)

“Exploring LHC Physics with ATLAS” January 2009
Plenary, Conference for Undergraduate Women in Physics (Yale)

“What is the Large Hadron Collider and what are we planning to do with it?” May 2008
Invited, Teacher’s Conference (Kavli Institute of Theoretical Physics, UCSB)

Synergistic activities

Berkeley Lab General Sciences Division Workplace Life committee member. August 2008 - November 2009.

Recent career panels for underrepresented groups: Graduate Women in Science Rho Tau Chapter (NIEHS, April 2010); Society of Women in the Physical Sciences (Berkeley, April 2008); Mellon Mays University Fellowship Annual Meeting (New York, 2007).

Identification of potential conflicts of interest or bias

Collaborators and co-editors

Benjamin, Douglas (Duke); Duehrssen, Michael (CERN); Gaponenko, Andrei (Lawrence Berkeley Laboratory); Hinchliffe, Ian(Lawrence Berkeley Laboratory); Kruse, Mark (Duke); Shapiro, Marjorie (Lawrence Berkeley Laboratory); Virzi, Joesph (Lawrence Berkeley Laboratory); Werner, Matthias (Albert-Ludwigs-Universitaet Freiburg)

Graduate and postdoctoral advisors and advisees

Franklin, Melissa E.B. (Harvard University) Graduate advisor

Shapiro, Marjorie (Lawrence Berkeley Laboratory) Postdoctoral sponsor

Curriculum vitae

Name:	**Douglas Paul Benjamin**
Citizenship:	United States
Current Position:	Research Scientist (Since Oct. 1998) Department of Physics, Duke University
Postal Address:	Department of Physics Box 90305 Duke University Durham, NC 27708-0305
Work Phone:	(630) 840 – 8432 (Fermilab)
e-mail address:	benjamin@phy.duke.edu

Research Interests:

Grid computing, with particular emphasis on data storage, transport and data discovery.
Design, fabrication and operation of tracking systems required for the study of heavy quark and electroweak and Higgs physics. Investigation of the interactions between Standard Model electroweak gauge bosons. Searches for the Higgs boson.

Current Activities:

- Higgs searches: participating in the Tevatron new physics and Higgs combination group. Collaborate with members of the CDF and D0 collaborations in producing combined Higgs results for both experiments. Participating in the CDF search for the Higgs boson in the $H \rightarrow WW$ channel.
- US Atlas Analysis facility Liaison and Tier 3 Support Group lead – Liaison between US Atlas Physicist community and Computing professionals supporting the US Atlas analysis farms at SLAC and BNL. Leader of the group of people providing support of the institutional computing centers (Tier 3) at the Universities. Have responsibility in specifying the details and installing the Tier 3 centers. Responsible for providing training and support.
- Atlas Transition Radiation Tracker (TRT) validation software. – Responsible for writing and maintaining software required to validate the simulation of the Atlas TRT in the offline software releases of the Atlas experiment at the CERN.

Previous Research Summary:

CDF offline:

- *CDF offline grid and analysis farm computing* (March 07 – Aug 08) – physicist responsible for the onsite dedicated analysis computing farm (CAF) and the OSG grid based computing. Shared responsibility with Italian colleagues on European LCG based computing. Lead a team of software developers and physicists to maintain our existing middleware and transitioning our computing from dedicated computer farms to grid based computing and tools.

  CDF CAF subproject leader (Feb. 06 to Nov 06) maintained the CAF middleware for the experiment and the managed the early transition from dedicated resources to grid based computing (Fermigrid nodes and OSG nodes).

  CDF data handling subproject co-leader (Feb. 05 to Oct. 06). Had responsibility for the storage and retrieval of the scientific data associated with CDF experiment. We managed and implemented transition between data handling systems for the entire experiment while the experiment was actively collecting and creating scientific data. In the CAF and data handling roles, I have collaborated with computing professions from the Fermilab computing division.

CDF electron/photon analysis code librarian - Developed and maintained the CDF electron and photon software for the 1992-93 collider run. Responsible for all of the electron and photon reconstruction and filtering software used in the CDF Level 3 trigger

Project Management :

Deputy project manager CDF Run IIb Detector Upgrade (Feb '02 – Oct. '06) Assisted the project manager in the management of the $8 million detector upgrade for the CDF detector the life from the project, from the approval phase through completion and closeout. This required developing and maintaining schedules, plans budgets, reports and reviews for the upgrade as well as working on the technical aspects of the project. Had to manage a team of scientists, engineers, computer professionals and technicians.

Detector :

Responsible Physicist Atlas Transition Radiation Tracker Barrel detector integration (Feb. '03 – Jun. '04) Co-lead a team of engineers and technicians in the verification and assembly of the Barrel TRT support structure (BSS) at CERN. Co-lead team of engineers, scientists and technicians to develop and implement the techniques and testing procedures to the TRT barrel module installation into BSS.

Responsible Physicist CDF SVX-II ladder fabrication (Mar 96 – Apr '00) Lead the effort to develop, design and manufacture the assembly techniques, jigs and fixtures fro the Silicon "ladder" detection elements of the SVX-II detector. Lead the silicon ladder assembly. The team included engineers, designers, drafts persons, technicians and scientists.

Education

February 1994	**Ph.D. - Physics** Tufts University Medford, Massachusetts

Thesis: Measurement of the Production Cross Section for W + γ in $\sqrt{s}$ = 1.8 TeV $\overline{p}p$ collisions.
Thesis Advisor: Krzysztof Sliwa

May 1984	**AB - Mathematics and Physics** Middlebury College Middlebury, Vermont

Brief Employment History

- **Oct 1998 – Present** Research Scientist, Duke University Physics Department
- **Oct 1997 – Sep 1998** Senior Research Associate Texas, Tech University Physics Department
- **Oct 1993 - Sep 1997** Research Associate, Texas Tech University Physics Department
- **Sep 1985 - Oct 1993** Graduate Research Assistant, Tufts University Physics Department
- **Sep 1989 - May 1990** Graduate Teaching Assistant, Tufts University Physics Department

Biographical Sketch

Gustaaf Brooijmans

Columbia University

Professional Preparation

- Undergraduate Institution: Université catholique de Louvain, major in physics, degree: Licence en Sciences Physiques (M.S.) 1993.
- Graduate Institution: Université catholique de Louvain, Ph.D. in physics, degree: Ph.D. 1998 (A New Limit on $\nu_\mu \rightarrow \nu_\tau$ Oscillations).
- Postdoctoral Institution: Fermi National Accelerator Laboratory (Fermilab), Experimental Particle Physics, 1998 to 2001.

Appointments

- Associate Professor at Columbia University from July 2009 to present.
- Assistant Professor at Columbia University from September 2003 to July 2009.
- Wilson Fellow at Fermi National Accelerator Laboratory from July 2001 to October 2003.
- Research Assistant at Fermi National Accelerator Laboratory from July 1998 to July 2001.
- Visiting Professor at the Centre de Physique des Particules de Marseille, France, November and December 2000.
- Research Assistant at the Institut Interuniversitaire des Sciences Nucléaires (IISN) in Belgium from August 1994 to July 1998.

Publications

Publications Related to the Proposed Project:

1. H. Abreu *et al.*, "Performance of the electronic readout of the ATLAS liquid argon calorimeters," JINST **5**, P09003 (2010),
2. G. Aad *et al.*, [ATLAS Collaboration], "Readiness of the ATLAS Liquid Argon Calorimeter for LHC Collisions," Eur. Phys. J. **C70**, 723-753 (2010), http://dx.doi.org/10.1140/epjc/s10052-010-1354-y.
3. M. Ullan *et al.*, "Evaluation of silicon-germanium (SiGe) bipolar technologies for use in an upgraded ATLAS detector," Nucl. Instrum. Meth. **A604**, 668-674 (2009), http://dx.doi.org/10.1016/j.nima.2009.03.177.
4. N. J. Buchanan *et al.*, "ATLAS liquid argon calorimeter front end electronics," JINST **3**, P09003 (2008), http://dx.doi.org/10.1088/1748-0221/3/09/P09003.

5. G. Aad *et al.*, [ATLAS Collaboration], "The ATLAS Experiment at the CERN Large Hadron Collider," JINST **3**, S08003 (2008), http://dx.doi.org/10.1088/1748-0221/3/08/S08003.

Other Publications:

1. V. M. Abazov *et al.*, [D0 Collaboration], "Evidence for an Anomalous Like-Sign Dimuon Charge Asymmetry," Phys. Rev. **D 82**, 032001 (2010), http://dx.doi.org/10.1103/PhysRevD.82.032001.
2. G. Brooijmans *et al.*, "New Physics at the LHC. A Les Houches Report: Physics at TeV Colliders 2009 - New Physics Working Group," CERN-PH-TH-2010-096, e-Print: arXiv:1005.1229 [hep-ph] , May 2010, http://arxiv.org/abs/1005.1229.
3. E. Eskut *et al.* [CHORUS Collaboration], " Final Results on $\nu_\mu \to \nu_\tau$ oscillation from the CHORUS experiment," Nucl. Phys. **B793**:326-343 (2008), http://dx.doi.org/10.1016/j.nuclphysb.2007.10.023.
4. G. Ambrosini *et al.* [NA56/SPY Collaboration], "Measurement of Charged Particle Production from 450-GeV/c Protons on Beryllium," Eur. Phys. J. **C10**, 605 (1999), http://dx.doi.org/10.1007/s100520050601.

Synergistic Activities

- Mentoring of students in the Nevis REU program.
- Mentoring of high school and undergraduate students; participation in the Fermilab Saturday Morning Physics program, introducing physics to high school students.
- Development of high bandwidth data acquisition systems based on commodity components.
- Member of various review committees: Temple Review of the BTeV and CKM experiments, Preliminary Baseline Review of the RSVP Project, Particle Data Group Advisory Committee.

Collaborators and Other Affiliations

Collaborators and Co-Editors

The SPY Collaboration, http://na56.web.cern.ch/NA56/.

The CHORUS Collaboration, http://choruswww.cern.ch/Collaboration/Individuals.html.

The DØ Collaboration, http://www-d0.fnal.gov/collaboration/people/gallery.html.

The ATLAS Collaboration, http://atlas.web.cern.ch/Atlas/internal/Welcome.html.

Graduate and Postdoctoral Advisors

Graduate Advisor: Prof. Denis Favart, Université catholique de Louvain.

Postdoctoral Advisor: Amber Boehnlein, Fermi National Accelerator Laboratory.

Thesis Advisor and Postgraduate-Scholar Sponsor

Sponsor of **7** *postdoctoral scholars:*

Tim Andeen, Dominik Dannheim, Thomas Gadfort, Andrew Haas, Francesco Spano, Lidija Živković, Columbia University and Nevis Laboratories; Martijn Mulders, Fermi National Accelerator Laboratory.

Thesis advisor for **5** *graduate students:*

Andrew Altheimer, Seth Caughron, Chad Johnson, Alex Penson, Dustin Urbaniec, Columbia University.

Gary Drake

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-1568
Fax: 630-252-5047
E-mail: drake@anl.gov

Education:

B.S.E.E., University of Wisconsin – Madison, 1982
M.S.E.E., University of Wisconsin – Madison, 1983

Professional Employment:

Senior Engineer, ANL (2008-)
Engineer, ANL (1997-2008)
Engineer, Fermilab (1983-1997)

Awards, Memberships, and Professional Service:

Member, IEEE (1994)
Argonne Pacesetter Award – June, 2007
Publications (18)
Additional published conference proceedings (25)
Unpublished technical reports (46)

Selected Research Accomplishments

Design Engineer, design and production of front-end electronics for the calorimeters of the CDF detector, Run I at Fermilab (1983-1989).
Design of custom integrated circuits (1994-1996).
Lead Project Engineer, design and production of front-end electronics for the Shower Maximum Detector for the CDF, Run II Upgrade at Fermilab (1995-1999).
Lead Project Engineer and Level 3 Manager, design and production of the readout instrumentation for the MINOS Near Detector at Fermilab (1999-2005).
Design of Cockroft-Walton photomultiplier base for the BCAL detector of the Zeus Experiment at DESY in Hamburg, Germany (1999-2000).
Design of a custom backplane for the Level 2 Trigger of the ATLAS Experiment at the LHC at CERN in Switzerland (2004-2005).
Development of beam monitoring electronics for the NuMI Beamline at Fermilab (2003-2005).
Telescope camera R&D for the TrICE Telescope at Argonne (2003-2006).
Lead System Engineer, design and production of readout instrumentation for Digital Hadron Detector R&D for CALICE (Detector R&D for the International Linear Collider) (2003-present).
Development of a 1-GHz Photon-Counting Custom Integrated Circuit for Ground-Based Air-Cherenkov Telescopes. (2005-2008).
Development of 1-Picosecond timing instrumentation for HEP applications (2005-present).
R&D on detector development using silicon photomultipliers (2006-2008).
Switching power supply support for the Barrel Calorimeter of the ATLAS Experiment at the LHC at CERN in Switzerland (2006-present).
Lead engineer, design of high-speed topological trigger for future telescope arrays for gamma-ray astronomy (2007-present).
Development of new switching power supplies for the upgrade of the Barrel Calorimeter of the ATLAS Experiment at the LHC at CERN in Switzerland (2008-present).
Development of new readout instrumentation for the upgrade of the Barrel Calorimeter of the ATLAS Experiment at the LHC at CERN in Switzerland (2008-present).

<u>Selected Publications (Gary Drake)</u>:

(1) "A New High-Speed Pattern Recognition Trigger for Ground-Based Telescope Arrays Used in Gamma-Ray Astronomy," *IEEE 2008 NSS Conf. Rec.*, 2008, 8 pages.

(2) "The MINOS Near Detector Front End Electronics *IEEE Trans. Nucl. Sci.*, vol. 53, 2006, pp. 1347-1355.

(3) "A Digital Hadron Calorimeter with Resistive Plate Chambers for the Linear Collider," *Int. J. Mod. Phys*, Vol. A20, 2005, pp. 3830-3833.

(4) "DCAL: A Custom Integrated Circuit for Calorimetry at the International Linear Collider," *IEEE 2005 NSS Conf. Rec.*, 2005, 8 pages.

(5) "The Shower Maximum Front-End Electronics for the CDF Upgrade," *IEEE Trans .Nucl. Sci.*, vol. 49, 2002, pp. 2567-2573.

(6) "The Upgraded CDF Front End Electronics for Calorimetry," *IEEE Trans. Nucl. Sci.*, vol. 39, 1992, pp. 1281-1285.

(8) "CDF Front End Electronics: The RABBIT System," *Nucl. Instrum. Meth.*, vol. A269, 1988, pp. 68-81.

(9) "A Large Dynamic Range Charge Amplifier ADC for the Fermilab Collider Detector Facility," *IEEE Trans. Nucl. Sci.*, vol. 33, 1986, pp. 893-896.

Maurice Garcia-Sciveres
Lawrence Berkeley National Laboratory
1 Cyclotron Rd., Berkeley, CA 94720

EDUCATION AND TRAINING

Hamilton College, B.A., 1988
Cornell University, Physics, Ph.D., 1994

RESEARCH AND PROFESSIONAL EXPERIENCE

2010-present	Senior staff, Lawrence Berkeley National Laboratory
2000-2010	Staff scientist, Lawrence Berkeley National Laboratory
1994-2000	Postdoctoral fellow, Lawrence Berkeley National Laboratory

SELECTED INSTRUMENTATION PUBLICATIONS

1. V. Zivkovic, et. al., "`The design for test architecture in digital section of the ATLAS FE-I4 chip," JINST 6, C01090 (2011) .
2. M. Garcia-Sciveres, et.al., "The FE-I4 Pixel Readout Integrated Circuit," Nucl. Instr. Meth. Phys. A, in press (2010) DOI:10.1016/j.nima.2010.04.101
3. M. Garcia-Sciveres, et.al., "System concepts for doublet tracking layers," JINST 5, C10001 (2010).
4. M. Garcia-Sciveres, et. al., "Development of silicon and carbon foam low mass interposers," JINST 5, C07008 (2010).
5. ATLAS collaboration, "ATLAS Insertable B-Layer Technical Design Report," CERN-LHCC-2010-013, (2009).
6. D. Arutinov, et. al. , "Digital architecture and interface of the new ATLAS pixel front-end IC for upgraded LHC luminosity.," IEEE Trans.Nucl.Sci. 56 (2009) 388-393.
7. M. Garcia-Sciveres [ATLAS Collaboration], "Post-installation status of the ATLAS pixel detector", JINST 4, P03021 (2009).
8. P. Denes, et.al. "A capacitor charge pump DC-DC converter for physics instrumentation," IEEE Trans. Nucl. Sci. 56:1507 (2009).
9. G. Aad et.al., "ATLAS pixel detector electronics and sensors," JINST 3,P07007 (2008).
10. M. Garcia-Sciveres et al., "The SVX4 integrated circuit", Nucl. Instr. And Meth. A 511:171-173, (2003).
11. A. Affolder, et al., "effect of dead-timeless silicon strip readout at CDF II," Nucl. Instrum. Meth. A 501:197 (2001).
12. M. Garcia-Sciveres et al., "The SVX3D integrated circuit for dead-timeless silicon strip readout", Nucl. Instr. And Meth. A 435:58-64, (1999).

SYNERGISTIC ACTIVITIES

2011	Co-organizer of ATLAS-CMS Electronics Workshop (ACES2011), CERN.
2011	LBNL Laboratory Directed R&D funding award for "High voltage Up- and Down-converters for Low Power Low Density Detector Instrumentation"
2010	Co-organizer of Workshop in Intelligent Trackers (WIT2010), LBNL.
2010-present	Level 2 Manager of Silicon Upgrades within US-ATLAS Project
2010-present	US-Atlas lead for Insertable B-Layer project

2008-2009 LBNL Laboratory Directed R&D funding award for “Development of silicon nanowire carpet hybrid pixel detectors”

2007-2008 ATLAS pixel detector operation coordinator

2001-present Member of review committees for GLAST, Babar, STAR, Nova, SNAP, HPS. Reviewer for SBIR program, IEEE, NIM, and JINST journals.

COLLABORATORS

2000-present	ATLAS collaboration
1994-2003	CDF collaboration
1989-1995	CLEO collaboration

Ph.D. Thesis Advisor: Prof. Persis Drell, SLAC National Accelerator Laboratory
Postocs mentored: Y. Lu (IHEP), W. Lu (IHEP), S. Dube (LBNL), L. Caminada (LBNL), S. Vahsen (now U. Hawwaii), A. Saavedra (now U. Sydney), I. Volobouev (now TTU).
Grad. Students mentored: A. Affolder, A. Connolly, A. Deisher, J. Muelmenstad, A. Deisher, M. Leyton, J. Freeman, P Loscutoff, A. Bach.

Alexander A. Grillo
Santa Cruz Institute for Particle Physics
University of California, Santa Cruz
1156 High St, Santa Cruz, CA 95064

EDUCATION AND TRAINING

Stanford University, Physics, B.S., 1971
State University of New York at Stony Brook, Physics, M.S., 1972
University of California Santa Cruz, Physics, Ph.D., 1980

RESEARCH AND PROFESSIONAL EXPERIENCE

1992-present	Research Physicist, Santa Cruz Institute for Particle Physics, University of California, Santa Cruz
1990-1992	Engineering Physicist, Stanford Linear Accelerator Center
1982-1992	Part-time Instructor, DeAnza College
1989-1990	Acting Director of Operations, Magnesys, Inc.
1988-1989	Director of Engineering, Magnesys
1985-1988	Device Engineering Manager, Magnesys
1984-1985	Manager of Statistical Modeling Group, Intel Corporation
1982-1984	Staff Test Engineer and Test Engineering Manager, Intel Magnetics, Inc.
1979-1982	Senior Product Engineer, Intel Magnetics, Inc.
1972-1979	Research Assistant and Teaching Assistant, University of California, Santa Cruz
1969-1971	Laboratory Assistant, High Energy Physics Laboratory, Stanford University

PUBLICATIONS

1. Evaluation of silicon-germanium (SiGe) bipolar technologies for use in an upgraded ATLAS detector, M. Ullán, A.A. Grillo, H.F.-W. Sadrozinski, *et al*., *Nucl. Instrum. Meth*ods **A604**, 668 (2009).

2. The ATLAS Experiment at the CERN Large Hadron Collider, The ATLAS Collaboration and G Aad *et al*., *JINST* **3** S08003 (2008).

3. The data acquisition and calibration system for the ATLAS Semiconductor Tracker, A. Abdesselam *et al.*, *JINST* **3** P01003 (2008).

4. The integration and engineering of the ATLAS SemiConductor Tracker Barrel, A. Abdesselam *et al.*, *JINST* **3** P10006 (2008).

5. The Optical Links of the ATLAS SemiConductor Tracker, A. Abdesselam *et al.*, *JINST* **2** P09003 (2007).

6. Performance of the BaBar Silicon Vertex Tracker, V. Re *et al.*, *Nucl. Instrum. Methods* **A501**, 14 (2003).
7. The BaBar Silicon Vertex Tracker, C. Bozzi *et al.*, *Nucl. Instrum. Methods* **A435**, 25 (1999).

SYNERGISTIC ACTIVITIES

2011	Member of the International Advisory Committee of the 8th International Meeting on Front-End Electronics, Bergamo, Italy.
2005-Present	Level 2 Manager of US-ATLAS Project, responsible for managing the US budget and operations work of the silicon subsystem covering 10 institutions.
2007-2008	Member of the International Advisory Committee of the 8th International Conference on Position Sensitive Detectors (PSD8), University of Glasgow, Scotland.
1995-2008	Coordinator of SCT Electronics Development for the ATLAS Collaboration, centered at the CERN Laboratory, Geneva, Switzerland.
2006-2007	Member of the International Advisory Committee of the XIth Vienna Conference on Instrumentation.
2006	Member of the Local Organizing Committee of the 6th International Hiroshima Symposium on the Development and Application of Semiconductor Tracking Detectors.

COLLABORATORS

I am a member of the ATLAS collaboration with approximately 3000 collaborators total. I have worked especially closely in the past few years with the following researchers:

Collaborators: Prof. Abraham Seiden (UC Santa Cruz), Prof. Hartmut Sadrozinski (UC Santa Cruz), Dr. Maurice Garcia-Sciveres (LBNL), Dr. Miguel Ullan (IMB-CNM,CSIC, Barcelona), Dr. Philippe Farthouat (CERN).
Graduate Advisor: Prof. David Dorfan, Department of Physics and Santa Cruz Institute for Particle Physics, University of California Santa Cruz.
Postdoctoral Scholars: Dr. Sofia Chouridou (UC Santa Cruz).

Carl Haber
Lawrence Berkeley National Laboratory
Physics Division

PROFESSIONAL PREPARATION

Columbia College	Physics	B.A.	1980
Columbia University	Physics	MPhil.	1982
Columbia University	Physics	Ph.D.	1985

POST DOCTORAL APPOINTMENTS

1985-1990	Physics Division, Lawrence Berkeley National Laboratory

APPOINTMENTS

1996-present	Senior Scientist, Physics Division, Lawrence Berkeley National
1990-1996	Staff Scientist, Lawrence Berkeley National Laboratory

SELECTED PUBLICATIONS PERTINENT TO THIS PROPOSAL

1. **Radiation damage experience at CDF with SVX'.** P. Azzi *et al.* **Nucl.Instrum.Meth.A383:155-158,1996**.
2. **The CDF Run IIB Silicon Detector.** (M. Aoki *et al.*) **Nucl.Instrum.Meth.A518:270-276,2004**
3. **Introductory Lectures on Tracking Detectors** C. Haber,. **AIP Conf.Proc.674:36-75,2003**
4. **The SVX4 Integrated Circuit,** M. Garcia-Sciveres et al., **Nucl. Instr. Methods A511:171-173, 2003**
5. **Precision Inner Tracking Systems at Future High Luminosity Hadron Colliders,** C. Haber**,** published in INNOVATIVE DETECTORS FOR SUPERCOLLIDERS Proceedings of the 42nd Workshop of the INFN ELOISATRON Project *Erice, Italy 28 September - 4 October 2003* edited by E Nappi *(INFN, Bari, Italy)* & J Seguinot *(College de France, Paris, France)*
6. **Development of large area integrated silicon tracking elements for the LHC luminosity upgrade.** J. Kierstead *et al.* **Nucl.Instrum.Meth.A579:801-805,2007**.
7. **The barrel modules of the ATLAS semiconductor tracker.** A. Abdesselam *et al.* **Nucl.Instrum.Meth.A568:642-671,2006**.
8. **The CDF Run IIb Silicon Detector: Design, preproduction, and performance.** T. Akimoto *et al.* **Nucl.Instrum.Meth.A556:459-481,2006**.
9. **Serial powering of silicon strip modules for the ATLAS tracker upgrade.** By Enrico Giulio Villani, C. Haber, R. Holt, P. Phillips, M. Tyndel, M. Weber. Nucl.Phys.Proc.Suppl.197:250-253,2009,.
10. **The ATLAS Inner Detector commissioning and calibration,** By ATLAS Collaboration [arXiv:1004.5293] (Apr 2010) 34p.

OTHER PUBLICATIONS

1. T. Affolder et al. [CDF Collaboration], **"Measurement of the top quark mass with the Collider Detector at Fermilab,"** Phys. Rev. D **63**, 032003 (2001)
2. D. Acosta et al., [CDF Collaboration], **"Measurement of B meson lifetimes using fully reconstructed B decays produced in p anti-p collisions at s**(1/2) = 1.8-TeV,"** Phys. Rev. D **65**, 092009 (2002).

3. D. Acosta et al,. [CDF Collaboration], **“Measurement of the lifetime difference between B(s) mass eigenstates”,** Phys. Rev. Lett. **94**, 10103 (2005).
4. A. Abulencia et. al., [CDF Collaboration], **“Precision top quark mass measurement in the lepton + jets topology in p anti-p collisions at s**(1/2) = 1.96-TeV,”** Phys. Rev. Lett. **96**:022004 (2006).
5. A. Abulencia et. al., [CDF Collaboration], **“Measurement of the B(c)+ meson lifetime using B(c)+ ---> J/psi e+ nu(e),”** Phys. Rev. Lett. **97**:012002 (2006)
6. Joao Barreiro Guimaraes da Costa *et al* [ATLAS Collaboration], "**Measurement of Dijet Azimuthal Decorrelations in pp Collisions at sqrt(s) = 7 TeV."** Feb 2011., 4pp. arXiv:1103.2696 [hep-ex]

SYNERGISTIC ACTIVITIES

Have had significant service roles for ATLAS, various laboratories, and other areas of physics and technology. Examples are given below.
2008-2009 Brookhaven Instrumentation Division review
NASA multiple Gamma Ray Large Area Space Telescope (GLAST) review panels
DOE Cost and Schedule review of the Compact Muon Solenoid
Brookhaven Lab Instrumentation review of the STAR project at the Relativistic Heavy Ion Collider (RHIC)
Brookhaven RHIC Detector Advisory Committtte (DAC)
Program Committee for the 2003 and 2004 IEEE Nuclear Science Symposia
2006 Engineer’s Roundtable for the National Sound Preservation Board
Consultant to the Preservation Advisory Committee of the National Archives and Records Administration

COLLABORATORS & OTHER AFFILIATIONS

a) Collaborators

I am a member of the ATLAS collaborations with approximately 3000 members. I was until recently a member of the CDF collaboration with approximately 500 members.
Recent individuals with whom I have worked closely include: Howard Gordon (BNL), Mike Tuts (Columbia), Abe Seiden (UCSC), Alex Grillo (UCSC), Phil Allport (Liverpool, U.K.), Nigel Hessey (Nikhef, Holland), Anthony Affolder (Liverpool, U.K.), Allan Clark (Geneva)

b) Graduate Advisor

Michael Shaevitz, Columbia University

c) Postdoctoral Advisor

William C. Carithers, Lawrence Berkeley National Laboratory

d) Advisees and other junior colleagues

Postdoctoral Scientists: Marc Weber (Karlsruhle), Igor Volobouev (Texas Tech)

JOHN D HOBBS
Department of Physics and Astronomy, Stony Brook University
Stony Brook, New York 11794-3800, Phone: 631-632-8107, Fax: 631-632-8101

I. EDUCATION

Cornell University	B.A. Physics	May, 1985
University of Chicago	Ph.D. Physics	March, 1991

II. PROFESSIONAL CAREER

2009–	Professor	Stony Brook University, NY; DØ and ATLAS experiments
2004–2009	Associate Professor	Stony Brook University, NY; DØ experiment
1998–2004	Assistant Professor	Stony Brook University, NY; DØ experiment
1996–1998	Wilson Fellow	Fermilab, Chicago, Illinois; DØ experiment
1993–1996	Post Doctoral Assoc.	Fermilab, Chicago, Illinois; DØ experiment
1991-1993	Scientific Assoc.	CERN, Geneva Switzerland; OPAL experiment

III. Publications

~600 Publications with the OPAL (~150), DØ (~400), and ATLAS Collaborations.

Five publications related to this proposal

1. "Readiness of the ATLAS Liquid Argon Calorimeter for LHC Collisions", The ATLAS Collaboration (G. Aad, *et al.*), EPJC **70** (2010).
2. "Search for the Associated Production of a b Quark and a Neutral Supersymmetric Higgs Boson that Decays into tau Pairs", Phys. Rev. Lett. **104** 151801 (2010).
3. "Search for the Standard Model Higgs Boson in the ZH->vvbb Channel in 5.2 fb-1 of ppbar Collisions at Root(s) = 1.96 TeV",the DØ Collaboration (V. Abazov *et al.*). Phys. Rev. Lett. **104** 071801 (2010).
4. "Measurement of the W boson mass," the DØ Collaboration (V. Abazov *et al.*). Phys. Rev. Lett. **103** 141801 (2009).
5. "The Upgraded DØ Detector", the DØ Collaboration (V.M. Abazov et al), Nucl. Instr. and Methods in Phys. **A**565, 463 (2006).

Five other significant publications

1. "Direct Measurement of the W Boson Width", Phys. Rev. Lett. **103** 231802 (2009).
2. "Evidence for Production of Single Top Quarks and 1st Measurement of $|V_{tb}|$", Phys. Rev. Lett. **98**, 181802 (2007).
3. "Direct Limits on the B_S^0 Oscillation Frequency", Phys. Rev. Lett. **97**, 021802 (2006).
4. "Observation of the Top Quark," the DØ Collaboration (S. Abachi *et al.*). Phys. Rev. Lett. **74** 2632-2637 (1995).
5. "Tests of the Electroweak Standard Model at the Energy Frontier", J. Hobbs, M. Neubauer, S. Willenbrock, Submitted to Reviews of Modern Physics.

IV. PROFESSIONAL ACTIVITIES

Chair, APS Tanaka Prize Committee, 2006

Deputy Chair, APS Tanaka Prize Committee, 2005

Member/chair of multiple DØ Editorial Boards (1995–)

Conference Organizer, multiple conferences

Invited conference talks, colloquia, and seminars

V. SYNERGISTIC ACTIVITIES

2009 – 2010	ATLAS experiment calorimeter uniformity studies
2005 – 2007	DØ Experiment Physics Co-Coordinator
2000 – 2004	DZero Silicon Track Trigger (STT) design and commissioning
2001 – 2003	DØ Higgs Search group co-convener

VI. COLLABORATORS

- OPAL Collaboration (http://opal.web.cern.ch/Opal/)
- Dzero Collaboration (http://www-d0.fnal.gov)
- ATLAS Collaboration (http://atlas.web.cern.ch/Atlas/Welcome.html)

VII. ADVISEES (Stony Brook: DØ and ATLAS)

1.	Yildirim Mutaf	PhD 2005; Prof, Univ of Pittsburgh (Medical)
2.	Satish Desai	PhD 2006; Fermilab post doc
3.	Huishi Dong	PhD 2007; Financial Industry
4.	Ken Herner	PhD 2008; Univ. of Mich. post doc
5.	Emanuel Strauss	PhD 2009; SLAC post doc
6.	Regina Caputo	PhD 2011 (expected)
7.	Rafael Lopes de Sa	PhD 2013 (expected)

Post docs supervised in past 5 years: Wendy Taylor (prof. York Univ.), Junjie Zhu (prof, Univ of Michigan), Dan Boline (current); total post docs supervised 7.

VIII. ADVISORS

- (Postdoctoral) A. Michelini (CERN); H. Montgomery (FNAL)
- (Ph.D. Thesis) J. Pilcher, Univ. of Chicago.

IX. AWARDS and HONORS

- DOE Outstanding Junior Investigator Award, 1998.

Joey Huston
Department of Physics and Astronomy
Michigan State University

Professional Preparation:

B.S. Physics (with University Honors) Carnegie-Mellon University 1976
M.A. Physics University of Rochester 1979
Ph.D Physics University of Rochester 1983
Thesis: “Radiative Width of the $\rho+$” Thesis advisor: Fred Lobkowicz

Appointments

Visiting Professor: Durham University, UK 2003-Present
Professor: Michigan State University 1998-Present
Associate Prof.: Michigan State University 1991-1998
Assistant Prof.: Michigan State University 1986-1991
Visiting Assistant Prof.: Michigan State University 1985-1986
Research Associate: University of Rochester 1983-1985

Selected Publications Related to this Proposal

1.Readiness of the ATLAS Tile Calorimeter for LHC collisions, [ATLAS Tilecal Collaboration], *Eur. Phys. J.* C **70**, 1193 (2010).

2. K. Anderson, T. Del Prete, E. Fullana, J. Huston, C.~Roda and R.~Stanek, Tilecal: The Hadronic Section Of The Central Atlas Calorimeter, *Int. J. Mod. Phys. A* **25**, 1981 (2010).

3. G. Aad *et al.* [Atlas Collaboration], Performance of the ATLAS Detector using First Collision Data, *JHEP* **1009**, 056 (2010).

4.P. Adragna *et al.*, [Atlas TileCal Collaboration], Testbeam studies of production modules of the ATLAS tile calorimeter, *Nucl. Instrum. Meth. A* **606**, 362-394 (2009).

5.J. Abdallah *et al.* [ATLAS TileCal Collaboration], The optical instrumentation of the ATLAS tile calorimeter, ATL-TILECAL-PUB-2008-005.

Other Publications

1.Hard Interactions of Quarks and Gluons: a Primer for LHC Physics, J. Campbell, J. Huston, W.J. Stirling, *Rept. Prog. Phys.* **70**, 89 (2007); http://stacks.iop.org/0034-4885/70/89.

2.Jets in Hadron-Hadron Collisions”, *Prog. Part. Nucl. Physics* **60**, 484 (2008), S. Ellis, K. Hatekayama, J. Huston, P. Loch, M. Toenessman

3.Inclusive Jet Production, Parton Distributions and the Search for New Physics, J. Huston et al., *JHEP* **0310**, 046 (2003).

4.Measurement of the Inclusive Jet Cross Section in $p\bar{p}$ Interactions at $\sqrt{s}$ =1.96-TeV Using a Cone-based Jet Algorithm," J. Huston et al. *Phys. Rev. D* **74**, 071103 (2006).

5.The Les Houches SM and NLO Multileg Working Group: Summary Report”, T. Binoth, J. Huston et al., arXiv:1003.1241.

JH has over 500 publications with greater than 30,000 citations including 8 renown papers (> 500 cites), 4 of which are experimental papers and 4 phenomenology.

d. Synergistic Activities:

JH is the co-spokesman of the CTEQ collaboration. He is a visiting professor at the Institute for Particle Physics at Durham University (UK) and has been invited as a Distinguished Visitor by the the Scottish Universities Physics Alliance (SUPA). He has given a series of lectures on LHC QCD physics at national meetings in the U.S., Canada, France and Germany, as well as ATLAS collaboration-wide. He has organized many workshops, including six at Les Houches, at Santa Barbara (a 3 month workshop at the Kavli Institute), at Cambridge University and at Fermilab (TeV4LHC, Higgs Physics at the Tevatron and LHC, Standard Model Benchmarks at the Tevatron and LHC). He delivered the plenary talk on QCD at the 1998 International Conference in High Energy Physics held in Vancouver and the plenary talk on Photon and Drell-Yan physics at the 1989 Lepton-Photon meeting at Stanford. He is one of the authors of the Handbook on Perturbative QCD, published by CTEQ in the Reviews of Modern Physics. He is one of the authors of the CTEQ parton distribution functions and has worked on developing many phenomenology tools (such as parton error pdf's , the Les Houches accords, the Les Houches NLO *wishlist*, PDF4LHC LHC cross section benchmarks) crucial for today's experimental analyses. He is the co-developer of *SpartyJet*, a framework to allow for very flexible jet reconstruction and analysis, in use at the Tevatron, LHC and phenomenology community. He has given a talk on the limits on jet precision at the Workshop on Detector R&D at Fermilab. He has organized many CTEQ summer schools as well as the first sub-Saharan school on high energy physics (South Africa, August 2010). JH was a member of the Fermilab Users Executive Committee from 1995-1996 and 2002-2003. He organized the 1995, 2002 and 2003 UEC trips to Washington. In 1996, he was appointed by the Fermilab director to an ad hoc Public Policy Committee to deal with relations with both Congress and the Administration. In 2007, he was elected to the first executive committee for the newly formed US LHC Users Organization.

He has published recent review articles on physics at the LHC and on jet production in hadron-hadron colliders. His review paper with John Campbell and James Stirling is one of the most downloaded articles for the ROP in recent years. He is expanding it into a book to be published by Oxford University Press. He has contributed a chapter to the book "At the Leading Edge: the ATLAS and LHC Experiments."

e. Collaborators and Other Affiliations:

i. Collaborators
   a. The CDF Collaboration, www-cdf.fnal.gov/cdfmemb.html
   b. The ATLAS Collaboration, graybook.cern.ch/programmes/experiments/ATLAS.html

ii. Graduate and Postdoctoral Advisors
   a. Ph.D thesis: Prof. Fred Lobkowicz, University of Rochester
   b. Postdoctoral advisor: Prof. Tom Ferbel, University of Rochester

iii. Thesis Advising and Postgraduate Scholar Sponsor
   a. Thesis advisor for Lee Sorrell, Simona Murgia, (Valeria Tano, Matthias Tonnesmann; formal advisor was Siggi Bethke but they were working with me on CDF as visitors at MSU), Gene Flanagan, Brian Martin, Mohammad Hussein, Ulrike Schnoor, Jessica Muir
   b. Postdoctoral advisor for John Mansour, Carlos Yosef, Ben Cooper, Andrea Messina, Mario Campanelli, Giorgi Arabidze

March 2011

KENNETH A. JOHNS
Physics Professor
Physics Department
University of Arizona
Tucson, AZ 85721
johns@physics.arizona.edu

CURRICULUM VITAE

Education

Ph.D., Physics, Rice University, 1986
"A Study of High Transverse Energy Events in Hadron-Hadron Collisions at $\sqrt{s} = 27$ GeV Using a QCD Monte Carlo Including Both Initial and Final State Gluon Bremsstrahlung" (Prof. Jay Roberts, Advisor)
M.A., Physics, Rice University, 1983
B.A., Physics, Rice University, 1981

Employment

Associate Physics Department Head, University of Arizona, 2009-present
Professor, University of Arizona, 2000-present
Associate Professor, University of Arizona, 1994 - 2000
Guest Scientist, Fermilab, 1996 - 1998
Assistant Professor, University of Arizona, 1989 - 1994
Research Associate, University of Minnesota, 1986 - 1989
Research Associate, Rice University, 1985 - 1986

Honors and Awards

NSF Presidential Young Investigator, 1991-1996

Synergistic Activities

Head of the Level 1 Calorimeter-Track Trigger Project for the D∅ experiment, 2002 - 2007
Head of the Level 1 Muon Trigger Project for the D∅ experiment, 1995 - 2007
Co-head of the Muon Detector Upgrade Project for the D∅ experiment, 1996 - 1999
Co-convener of the B Physics Group for the D∅ experiment, 1993 - 1996
Co-spokesperson of Fermilab Experiment E-800, 1989 - 1994
Spokesperson of Fermilab Experiment E-821, 1990 - 1994

Current Interests

Top quark production cross section measurements and searches for Beyond the Standard Model physics involving top quarks at ATLAS, development of next generation signal processing and readout for high luminosity collider experiments, front-end electronics development for muon micromegas detectors

Selected Publications

"Measurement of the Top Quark-Pair Production Cross Section with ATLAS in pp Collisions at $\sqrt{s}$ =7 TeV"
ATLAS Collaboration, G.Aad *et al*., submitted to EPJC(2010).

"The ATLAS Experiment at the CERN Large Hadron Collider",
ATLAS Collaboration, G.Aad *et al*., JINST **3**:S08003 (2008).

"Measurement of the Top Quark Mass in the Dilepton Channel"
DØ Collaboration, V.M. Abazov *et al*., Phys. Lett. B **655**, 7 (2007).

"Search for Right-handed W Bosons in Top Quark Decay"
DØ Collaboration, V.M. Abazov *et al*., Phys. Rev. D **72**, 011104 (2005).

"Measurement of the $t\bar{t}$ Production Cross Section in $p\bar{p}$ Collisions at $\sqrt{s}$ =1.96 TeV in Dilepton Final States"
DØ Collaboration, V.M. Abazov *et al*., Phys. Lett. B **626**, 55 (2005).

"The Level 1 Muon Trigger for Run II of DØ",
DØ Collaboration, J. Steinberg *et al*., IEEE Trans. Nucl. Sci. **44**, 348 (1997).

"Precision Measurement of the Ω^- Magnetic Moment",
E-800 Collaboration, N.B. Wallace *et al*., Phys. Rev. Lett. **74**, 3732 (1995).

Collaborators and Other Affiliations

a) Collaborators
I am a member of the ATLAS and DØ collaborations.

b) Graduate Advisor
Jay Roberts, Rice University

c) Postdoctoral Advisors
Ken Heller, Marvin Marshak, University of Minnesota

d) Advisees
Graduate Students: Susan Burke, Kevin Davis, Dave Fein, Bryan Gmyrek, Eric James, Xiaowen Lei (current), Rob McCroskey, Ajay Narayanan, Alex Smith, Jeff Temple, Jason Veatch (current), Dave Vititoe
Postdoctoral Associates: Stefan Anderson, Joan Guida, Venkat Kaushik (current), Leigh Markosky, Freedy Nang, Noah Wallace

Biographical Sketch

Mark Charles Kruse

Department of Physics, Duke University, Durham, NC 27708-0305
URL: `http://www.phy.duke.edu/~mkruse/`

Education and Training

B. Sc., Auckland University (New Zealand), 1986 (Physics)

M. Sc., Auckland University (New Zealand), 1988 (Physics, 1^{st}-class honours)
Thesis Title: "Yrast Spectroscopy of ^{206}Po"

Ph.D., Purdue University, 1996 (Physics)
Thesis Title: "Observation of $t\bar{t}$ Production in the Dilepton + Jets Decay Channel from Proton-Antiproton Collisions at $\sqrt{s} = 1.8\,\mathrm{TeV}$"

Postdoctoral fellowship, University of Rochester (NY), 1996-2000 (High-Energy Particle Physics)

Research and Professional Experience

Jul 2007 - present, Associate Professor of Physics, Duke University.
ATLAS Experiment at the LHC (TRT, top physics), ATLAS silicon detector upgrade,
CDF Experiment at Fermilab (SVX-II, Higgs and top physics)

Sep 2000 - Jul 2007, Assistant Professor of Physics, Duke University.
CDF Experiment, ATLAS experiment

Mar 1996 - Aug 2000, Postdoctoral Fellow, University of Rochester (New York).
CDF Experiment: designed/implemented silicon detector interlock and power supply control system

Aug 1990 - Feb 1996, Research Assistant, Purdue University (Indiana, USA).
CDF Experiment: silicon detector DAQ

Feb 1989 - Jul 1990, Scientist, National Radiation Laboratory, Christchurch, New Zealand.
Radiation physicist in medical physics before coming to US for graduate school.

Selected Publications

1. A. Abulencia *et al.* (CDF collaboration), "Inclusive Search for Standard Model Higgs Boson Production in the WW Decay Channel using the CDF II Detector", Phys. Rev. Lett. 104, 061803 (2010).

2. A. Abulencia *et al.* (CDF collaboration), "Search for Higgs Bosons decaying to pairs of W-Bosons", Phys. Rev. Lett. 102, 021802 (2009); arXiv:0809.3930. *(thesis analysis of my grad student D. Hidas)*

3. A. Abulencia *et al.* (CDF collaboration), "Cross Section Measurements of High-p_T Dilepton Final-State Processes Using a Global Fitting Method", Phys. Rev. D78, 012003 (2008). *(thesis analysis of my grad student S. Carron)*

4. T. Akimoto *et al.*, "The CDF Run IIb Silicon Detector: Design, preproduction, and performance", Nucl.Instrum.Meth. A556:459-481 (2006).

5. A. Abulencia *et al.* (CDF Collaboration), “Search for a Neutral Higgs Boson Decaying to a W Boson Pair in $p\bar{p}$ Collisions at $\sqrt{s} = 1.96$ TeV”, Phys. Rev. Lett. 97, 081802 (2006); hep-ex/0605124. *(thesis analysis of grad student S. Chuang whom I mentored: this was the pioneering $H \to WW$ analysis at CDF)*

6. D. Acosta *et al.* (CDF Collaboration), “Search for Higgs Bosons Decaying into $b\bar{b}$ and Produced in Association with a Vector Boson in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV”, Phys. Rev. Lett. 95, 051801 (2005). *(First combination of Higgs search results, done with W. Yao (LBL))*

7. M.C. Kruse [for the CDF and DØ Collaborations], “Silicon Detector Upgrades for the Tevatron Run 2”, Proceedings of, *31st International Conference on High Energy Physics (ICHEP 2002), Amsterdam, The Netherlands, 24-31 Jul 2002*, FERMILAB-CONF-02-253-E, Oct 2002. Published in “Amsterdam 2002, ICHEP”, 885-887
   `http://www-lib.fnal.gov/archive/2002/conf/Conf-02-253-E.html`

Synergistic activities

Co-convener of the “Higgs Discovery Group” at CDF (2007-2009)

Faculty advisor for Society of Physics Students at Duke (2009 - present)

Undergraduate Curriculum Committee, Duke (2009 - present)

Recent outreach activities: Public Talk on the LHC, Duke (scheduled for April 22 2011); Talk at American Association of Physics Teachers (AAPT) meeting, Raleigh NC, “Teaching the physics of the LHC to high-school students” (26 March 2011)

Have given several invited conference plenary talks and colloquia (see webpage for details)

Mentored several postdocs (see webpage for details)

Mentored/Advised several graduate students (see webpage for details)

Mentored/Advised several Duke undergraduate students (see webpage for details)

Identification of potential conflicts of interest or bias

Collaborators and co-editors: Arce, Ayana (Duke); Benjamin, Douglas (Duke); Goshaw, Al (Duke); Herndon, Matthew (Wisconsin); Konigsberg, Jacobo (Florida); Kotwal, Ashutosh (Duke); Oh, Seog (Duke); Roser, Robert (Fermilab)

Graduate and postdoctoral Advisors: Bortoletto, Daniela (Purdue, graduate advisor); Tipton, Paul (Yale, postdoctoral advisor)

Postdoctoral Advisees: Cabrera, Susana (U. of Valencia, postdoc 2001-2004); Necula, Valentin (U. of Florida, postdoc 2007-2008); Bocci, Andrea (2005 - present); Klinkby, Esben (Neils Bohr Institute, postdoc 2008 - 2010)

Graduate Student Advisees: Carron, Sebastian (postdoc at Fermilab); Hidas, Dean (postdoc at Rutgers)

Francesco Lanni

BROOKHAVEN
NATIONAL LABORATORY

OFFICE
Brookhaven National Laboratory
Physics Dept. - Bldg. 510a
Upton, NY, 11973 - USA

PHONE
+1 (631) 344 4865

FAX
+1 (631) 344 5078

EMAIL
flanni@bnl.gov

Education and Training

- M.S. Physics, University of Milan, Italy - 1991
- Ph. D. Physics, University of Parma, - 1995
- Postdoctoral Research, INFN Milan, Italy 1995-1998

Research and Professional Experience

- Deputy Group Leader, Omega Group - Physics Dept. (BNL) since Oct 2008
- Physicist (BNL) 2002-present
- Associate Physicist (BNL) 2000-2002
- Assistant Physicist (BNL) 1998-2000

Selected Detector and Instrumentation Related Publications

1. G. Aad et al., *Readiness of the ATLAS Liquid Argon Calorimeter for LHC Collisions*, Eur. Phys. J. C70 (2010) pp. 723-753
2. H. Chen et al., *Cryogenic Readout electronics R&D for MicroBooNE and beyond*, Nucl. Instr. and Methods A623 (2010) 391-393
3. H. Abreu et al., *Performance of the electronic readout of the ATLAS liquid argon calorimeters*, JINST 5 (2010) P09003
4. G. Aad et al., *Performance of the ATLAS Detector using First Collision Data*, JHEP 1009 (2010) 056
5. S. Dhawan et al., *Commercial buck converters and custom coil development for the ATLAS inner detector upgrade*, IEEE Trans. Nucl. Sci. vol. 57 (2010) pp. 456-462
6. G. Aad et al, *Expected Performance of the ATLAS experiment - Detector, Trigger and Physics*, Jan 2009 - e-Print: arXiv: 0901.0512 [hep-ex]
7. N. J. Buchanan et al, *Radiation qualification of the front-end electronics for the readout of the ATLAS liquid argon calorimeters*, JINST 3 (2008) P10005
8. N. J. Buchanan et al, *ATLAS liquid argon calorimeter front-end electronics*, JINST 3 (2008) P09003
9. G. Aad et al, *The ATLAS Experiment at the CERN Large Hadron Collider*, JINST 3 (2008) S08003
10. B. Aubert et al., *The BaBar detector*, Nucl. Instr. and Methods A479 (2002) 1-116

Synergistic Activities

- Co-organizer of ATLAS-CMS Electronics Workshop (ACES2011), CERN Mar 2011
- Convener and co-chair of the session "*Operating calorimeters and calibration*" at the XIV International Conference on Calorimetry in High Energy Physics, (CALOR2010) - May 2010, Beijing, China
- Principal investigator (2009-present) of an approved laboratory directed R&D (LDRD) on the developments of Liquid Argon Time Projection chambers for future neutrino experiments.
- Regularly chairing and/or organizing several internal ATLAS reviews, workshops, meetings on current status or future strategies and directions for upgrades.

Collaborators

- ATLAS collaboration: 1998 - present
- MicroBooNE and LArTPC for LBNE collaboration: 2007 - present
- BaBar collaboration:1995-1998
- KEDR collaboration: 1989-1994

Graduate and Postdoctoral Advisors

- Graduate Advisor: Prof. F. Palombo, Universita' degli Studi di Milano, Italy
- Postdoctoral Advisor: Prof. F. Palombo, Universita' degli Studi di Milano, Italy

David Lynn Biographic Sketch

Personal Information

David Lynn
Brookhaven National Laboratory
Physics Department
Upton, NY 11973
Phone: 631-344-4560
Email: dlynn@bnl.gov

Education

University of California, Los Angeles, Ph.D., 1994

Thesis: Measurement of K_s and Charm Production with a Microvertex Detector at the Super-Proton-Synchrotron Collider

University of California, Los Angeles, M.S. Physics – 1988

Massachusetts Institute of Technology, B.S. Mathematics, 1986

Massachusetts Institute of Technology, B.S. Physics, 1986

Research and Professional Experience

Physicist – 1999-Present, Brookhaven National Laboratory

Participating in upgrade of the ATLAS experiment's inner detector.

Designed silicon strip detectors and readout for the PP2PP Experiment at RHIC.

Installed, commissioned, and maintained the STAR silicon vertex tracker (a silicon drift detector) at RHIC.

Associate Physicist - 1997-1999**,** Brookhaven National Laboratory

Developed front-end electronics for the STAR silicon vertex tracker.

Developed silicon drift detector array for the E896 experiment at the AGS.

Assistant Physicist - 1995-1997, Brookhaven National Laboratory

Developed front-end electronics for the STAR silicon vertex tracker.

Research Assistant - 1988-1994, University of California, Los Angeles, (located at CERN, the European Organization for Nuclear Reasearch, Geneva, Switzerland)

Developed silicon detector system for the P238 project at the SPS; this featured silicon strip detectors installed in Roman Pots.

Teaching Assistant - 1986-1988, University of California, Los Angeles

Research Assistant – 1985, MIT Bates Linear Accelerator

Publications

D. Lynn, J, Kierstead, P. Kuczewski, M. Weber, C. Musso, J. Matheson, P. Phillips, G. Villani, "Serial power protection for ATLAS silicon strip staves", Nuclear Instruments and Methods in Physics Research A, Volume 633, Pages 51-60, 2011

J. Kierstead, Z. Li, D. Lissauer, D. Lynn, Y. Semetzvidis, K. Baker, K. MacFarlane, R.P. Ely, C. Haber, M. Gilchriese, W. Miller, A. Tuononen, G. Villani, M. Weber, "Development of large area integrated silicon tracking elements for the LHC luminosity upgrade", Nuclear Instruments and Methods in Physics Research A, Volume 579, Pages 801-805, 2007

S. Dhawan, O. Baker, H. Chen, R. Khanna, J. Kierstead, F. Lanni, D. Lynn, C. Musso, H. Smith, P. Tipton, M. Weber, "Commercial Buck Converters and Custom Coil Development for the Atlas Inner Detector Upgrade" IEEE Transactions on Nuclear Science, Volume 57, no. 2, Pages 456-462, 2010

M. Trimpl, G. Deptuch, C. Gingu, R. Yarema, R. Holt, M. Weber, J. Kierstead, D. Lynn, "The SPi chip as an integrated power management device for serial powering of future HEP experiments", Proceedings of the 18th International Workshop on Vertex Detectors, Published online at http://pos.sissa.it/cgi-bin/reader/conf.cgi?confid=95, p30, 2009

Z. Li, W. Chen, Y.H. Guo, D. Lissauer, D. Lynn, V. Radeka, G. Pellegrini, "Development, simulation and processing of new 3D Si detectors", Nuclear Instruments and Methods in Physics Research A, Volume 583, Pages 139-148, 2007

S. Bültmann, W. Chena, I.H. Chianga, R.E. Chriena, A. Dreesa, R.L. Gilla,W. Guryna, J. Landgrafa, Z. Lia, T.A. Ljubicic, D. Lynn, C. Pearson, P. Pile,V. Radeka, A. Rusek, M. Sakitt, R. Scheetz, S. Tepikian, J. Chwastowski, B. Pawlik, M. Haguenauer, A.A. Bogdanov, S.B. Nurushev, M.F. Runtzo, M.N. Strikhanov, I.G. Alekseev, V.P. Kanavets, L.I. Koroleva, B.V. Morozov, D.N. Svirida, A. Khodinov, M. Rijssenbeek, C. Tang, L. Whitehead, S. Yeung, K. De, N. Guler, J. Li, N. Öztük, A. Sandacz, "The PP2PP experiment at RHIC: silicon detectors installed in Roman Pots for forward proton detection close to the beam", Nuclear Instruments and Methods in Physics Research A, Volume 535, Pages 415-420, 2004

D. Lynn, R. Bellwied, R. Beuttenmuller, H. Caines,W. Chen, D. DiMassimo, H. Dyke, D. Elliot, V. Eremin, M. Grau, G.W. Hoffmann, T. Humanic, I. Ilyashenko, I. Kotov, H.W. Kraner, P. Kuczewski, B. Leonhardt, Z. Li, C.J. Liaw, G. LoCurto, P. Middelkamp, R. Minor, M. Munhoz, G. Ott, S.U. Pandey, C. Pruneau, V. Rykov, J. Schambach, J. Sedlmeir, B. Soja, E. Sugarbaker, J. Takahashi, K. Wilson, R. Wilson, "The STAR silicon vertex tracker: a large area silicon drift detector", Nuclear Instruments and Methods in Physics Research A, Volume 447, Pages 264-273, 2000

D. Lynn, R. Bellwied, R. Beuttenmueller, H. Caines, W. Chen, D. DiMassimo, H. Dyke, D. Elliott, M. Grau, G.W. Hoffman, T. Humanic, P. Jenson, S.A. Kleinfelder, I. Kotov, H. W. Kraner, P. Kuczewski, B. Leonhardt, Z. Li, C.J. Liaw, G. LoCurto, P. Middelkamp, R. Minor, N. Mazeh, S. Nehmeh, P. O'Conner, G. Ott, S.U. Pandey, C. Pruneau, D. Pinelli, V. Radeka, S. Rescia, V. Rykov, J. Schambach, J. Sedlmeir, J. Sheen, B. Soja, D. Stephani, E. Sugarbaker, J. Takahashi, K. Wilson, "A 240-channel thick film multi-chip module for readout of silicon drift detectors", Nuclear Instruments and Methods in Physics Research A, Volume 439, Pages 418-426, 2000

Synergistic Activities

DC-DC converter development with Yale University.

Collaborators and Co-editors

ATLAS Experiment, STAR Experiment, PP2PP Experiment

Thesis Advisor

Prof. Peter Schlein, University of California, Los Angeles

Mitch Newcomer
University of Pennsylvania
Department of Physics and Astronomy

PROFESSIONAL PREPARATION

University of Pennsylvania	Physics	B.A.	1976
University of Pennsylvania	Grad School		1977-78

Professional Positions

Instrumentation Specialist/Electronics Engineer   University of Pennsylvania, 1978- Present

Continuing Education

Various courses in Low noise, Low Power Bipolar and CMOS integrated circuit design. 1995 to 2009.

Experimental Physics Contributions

1978-83	BNL experiment 734 Testing and Design of gain Stabilization System, testbeam.
1984-1990	KamiokandeII 1000 channel PMT detector primary designer of the Front end Electronics Q and T readout. Recipient of Rossi Award for participation in the Discovery of SN1987A.
1988-1990	FNAL E771 Collaborated with FNAL on the design of 3 Front End Electronics ASICs
1990-1992	Design of the ASD8 for SDC at SSC. (300K channels instrumented world wide.)
1992-1996	Lead Designer of the Front End Electronics for the Sudbury Neutrino Detector .
1996-1999	Design of the CDF Central Open Tracker Front end upgrade including the ASDQ ASIC.
1997-1999	Lead Designer of CDF TOF front end electronics.
1995-2004	Design of the ATLAS TRT Front End electronics including the ASDBLR Contributions to the DTMROC ASIC design and Front End boards implementing ASICs.
2007-present	Contributions to the ATLAS Upgrade Electronics including SCT ABCn I/O, Serial Powering and participation in Strips Readout Working group.
2007-present	LSST CCD Camera readout electronics front end electronics design (Front End Board).

SELECTED PUBLICATIONS PERTINENT TO THIS PROPOSAL

1. *New Concepts in Powering for the LHC Upgrade*, F M Newcomer, POS (Vertex 2010) 003.
2. *Design and performance of the ABCN-25 readout chip for ATLAS inner detector upgrade*, W. Dabrowski, et. al., IEEE NSS Conf. Rec. 2009, p373-380.
3. *Radiation Hardness Studies of a 130nm Silicon Germanium BiCMOS technology with a dedicated ASIC*, S. Diez et. al. TWEPP 09, Workshop Proceedings, 2009.
4. *A SiGe ASIC Prototype for the ATLAS LAr Calorimeter Front-End Upgrade*, M. Newcomer et. al. **,** TWEPP 09, Workshop Proceedings, 2009.
5. *Evaluation of silicon-germanium (SiGe) bipolar technologies for use in an upgraded ATLAS detector*, NIM, A604, (2009) pg. 668,674.
6. *CDF central outer tracker*, Anthony Affolder et. al. Nucl.Instrum.Meth. A526 (2004) 249-299.
7. *A time-of-flight detector in CDF-II, CDF-II Collaboration*, NIM A518 (2004) 605-608.

SYNERGISTIC ACTIVITIES

Current Member Scientific Committee, TWEPP (Topical Workshop on Electronics for Particle Physics)

COLLABORATORS & OTHER AFFILIATIONS

a) Collaborators

I am a member ATLAS collaborations with approximately 3000 members.

Recent individuals with whom I have worked closely include:

Francis Anghinolfi, CERN Microelectronics group
Philippe Farthouat, CERN PH-AT group
Alexander Grillo, UCSC SCIPP
Ned Spencer, UCSC SCIPP
John Oliver, Harvard
Paul Oconnor, BNL Instrumentation Division
Sergio Rescia, BNL Instrumentation Division
Peter Philipps, RAL
Tony Affolder, Liverpool
Ashley Grenall, Liverpool

Jason A. Nielsen
Department of Physics
Santa Cruz Institute for Particle Physics
University of California, Santa Cruz
1156 High St, Santa Cruz, CA 95064

EDUCATION AND TRAINING

Iowa State University, Physics and Mathematics, B.S., 1994
University of Wisconsin-Madison, Physics, M.S., 1996
University of Wisconsin-Madison, Physics, Ph.D., 2001
Lawrence Berkeley National Laboratory, Physics Division Postdoctoral Fellow, 2001-2006

RESEARCH AND PROFESSIONAL EXPERIENCE

2006-present	Assistant Professor, Department of Physics, University of California, Santa Cruz
2006-present	Faculty Affiliate, Santa Cruz Institute for Particle Physics
2008	Visiting Scientist, IRFU CEA Saclay
2001-2006	Postdoctoral Fellow, Physics Division, Lawrence Berkeley National Laboratory
1995-2001	Graduate Research Assistant, University of Wisconsin-Madison
1993-1994	Undergraduate Research Assistant, Iowa State University

PUBLICATIONS

1. Limits on Upgrade Tracker Layout from Particle Fluxes, Signal-to-Noise and Occupancy
   H. F.-W. Sadrozinski *et al.,* submitted to Nucl. Instrum. Meth. A. (2011)

2. Studies of data transmission on long polyimide cables
   M. Norgren *et al.*, IEEE Nuclear Science Symposium (NSS/MIC), (2009)

3. The ATLAS Experiment at the CERN Large Hadron Collider
   G. Aad *et al.* (ATLAS Collaboration), JINST 3 (2008) S08003.

4. Production of Jets in Association with Z Bosons
   G. Aad *et al*. (ATLAS Collaboration), published in *Expected Peformance of the ATLAS Experiment: Detector, Trigger and Physics* (CERN 2008) pp. 777-787.

5. Status and Performance of the CDF Run 2 Silicon Detectors
   J. Nielsen (CDF Collaboration), Nucl. Instrum. Meth. A 560, 18 (2006).

6. Performance of the BaBar silicon vertex tracker
   V. Re *et al.,* Nucl. Instrum. Meth. A 501, 14 (2003).

7. The BaBar silicon vertex tracker
   C. Bozzi *et al.,* Nucl. Instrum. Meth. A 435, 25 (1999).

SYNERGISTIC ACTIVITIES

2008-2011 Graduate program committee (UC Santa Cruz Dept of Physics)
2008 Mentor for Paso Robles Endeavor Academy experimental “Balloon Fest”
2007-2008 Graduate student mentoring committee (UC Santa Cruz Dept of Physics)
2006-2008 Reviewed and revised undergraduate laboratory curriculum (UC Santa Cruz Dept of Physics)

COLLABORATORS AND CO-EDITORS

I am a member of the ATLAS and CDF collaborations, with approximately 3000 collaborators total. I have worked especially closely in the past few years with the following researchers:

Collaborators: Prof. Abraham Seiden (UC Santa Cruz), Prof. Bruce Schumm (UC Santa Cruz), Prof. Benjamin Brau (Massachusetts), Dr. Maarten Boonekamp (CEA Saclay), Prof. Beate Heinemann (UC Berkeley), Prof. Joey Huston (Michigan State Univ.), Prof. Ariel Schwartzman (SLAC), Dr. Alessandro Tricoli (CERN), Dr. Jeff Tseng (Oxford), Prof. Igor Volobouev (Texas Tech Univ.), Dr. Weiming Yao (LBNL)
Graduate Advisor: Prof. Sau Lan Wu, Department of Physics, University of Wisconsin-Madison
Postdoctoral Sponsor: Dr. Angela Galtieri, Physics Division, Lawrence Berkeley National Laboratory
Graduate Advisees: Mr. Daniel Damiani (UC Santa Cruz), Mr. Gabriel Hare (UC Santa Cruz), Mr. Andrew Kuhl (UC Santa Cruz)
Postdoctoral Scholars: Dr. Sofia Chouridou (UC Santa Cruz), Dr. Jovan Mitrevski (UC Santa Cruz)

Mark J. Oreglia
The University of Chicago
Physics Department and The Enrico Fermi Institute
5640 S. Ellis Avenue
Chicago, IL 60637
Phone: 1-773-702-7446
email: m-oreglia@uchicago.edu

Professional Preparation:

Stanford University	Physics	B.S. 1974
Stanford University	Physics	Ph.D 1981

Postdoctoral Appointments:

1981 SLAC
1981-1984 Enrico Fermi Fellow, The University of Chicago

Appointments:

2009-2010	Acting Director, The Enrico Fermi Institute
2001-present	Professor of Physics, University of Chicago
1991-2001	Associate Professor of Physics, University of Chicago
1984-91	Assistant Professor of Physics, University of Chicago

Selected Publications Pertinent to This Proposal:

1. *Readiness of the ATLAS Tile Calorimeter for LHC collisions.*
   The ATLAS Collaboration, . CERN-PH-EP-2010-024, Jul 2010; submitted to EPJC. e-Print: arXiv:1007.5423 [physics.ins-det]

2. *Testbeam studies of production modules of the ATLAS tile calorimeter.*
   P. Adragna *et al.* ATL-TILECAL-PUB-2009-002, ATL-COM-TILECAL-2009-004, Mar 2009. 74pp.
   Published in Nucl.Instrum.Meth.A606:362-394,2009.

3. *Study of energy response and resolution of the ATLAS barrel calorimeter to hadrons of energies from 20 to 350 GeV*, ATLAS Collaboration (E. Abat *et al.*), Nucl. Instr. and Meth. **A621**, 134 (2010).

4. *Design of the front-end analog electronics for the ATLAS tile calorimeter*, ATLAS Collaboration (K. Anderson *et al*.), Nucl. Instr. and Meth. **A551**, 469 (2005).

Other Selected Publications:

1. *Measurement of the production cross section for W-bosons in association with jets in pp collisions at sqrt(s) = 7 TeV with the ATLAS detector.* By ATLAS Collaboration (*et al.*) CERN-PH-EP-2010-081, Dec 2010. 26pp Submitted to Phys.Lett.B ; e-Print: **arXiv:1012.5382** [hep-ex]

2. *International Linear Collider Reference Design Report Volume 2: PHYSICS AT THE ILC*, Abdelhak Djouadi, Joseph Lykken, Klaus Monig, Yasuhiro Okada, Mark J. Oreglia, Satoru Yamashita . Sep 2007. e-Print: arXiv:0709.1893 [hep-ph]

3. S. Dawson and M.Oreglia, *Physics Opportunities with a TeV linear collider*, Ann. Rev. Nucl. Part. Sci. 2004 54:269 [arXiv:hep-ph/0403015].

4. The LEP Collaborations (R. Barate *et al*.), *Search for the standard model Higgs boson at LEP*, Phys. Lett. B565, 61 (2003) [arXiv:hep-ex/0306033].

5. OPAL Collaboration (G. Abbiendi *et al*.), *Search for the Standard Model Higgs Boson with the OPAL Detector at LEP*, Eur. Phys. J. **C**26, 479 (2003) [arXiv:hep-ex/0209078].

Synergistic Activities:

- Director and creator of *Enrico Fermi Summer Interns Program* for Chicago Public Schools minority and female 7th-graders; advisor to CEMSE
- PI, NSF umbrella grant for the U Chicago HEP group
- Member, ATLAS Speakers Committee
- Co-chair, American Linear Collider Physics Group

Collaborators and Other Affiliations:

a) Collaborators & co-editors:
Jim Brau (U. Oregon)
Sally Dawson (BNL)
ATLAS collaboration

b) Graduate Advisor, postdoctoral sponsor: Elliot Bloom (SLAC)

c) Postdoctoral Sponsor: Frank Merritt (U Chicago)

d) Graduate students (last 5 years):
Andy Hocker (FNAL)
Pedro Amaral (Lisbon U)
Chris Meyer (current)
Sam Meehan (current)

e) Postgraduate Students (last 5 years):
Kara Hofmann (U Maryland)
Ambreesh Gupta (private industry)
Peter Onyisi (current)

Lawrence Price
High Energy Physics Division
Argonne National Laboratory

PROFESSIONAL PREPARATION

Pomona College	Physics	BA	1965
Harvard University	Physics	MA	1966
Harvard University	Physics	PhD	1970

APPOINTMENTS

1992-2005	Division Director, Argonne National Laboratory
1988-Present	Senior Physicist, Argonne National Laboratory
1979-88	Physicist, Argonne National Laboratory
1978-79	Assistant Physicist, Argonne National Laboratory
1971-78	Assistant Professor, Columbia University
1970-71	Postdoc, Columbia University

SELECTED PUBLICATIONS PERTINENT TO THIS PROPOSAL

1. ATLAS Collaboration (G. Aad et al.). “The ATLAS Experiment at the CERN Large Hadron Collider”, JINST 3:S08003,2008
2. ATLAS/Tilecal Collaboration (Z. Ajaltouni, et al.), "Response of The Atlas Tile Calorimeter Prototype to Muons", *Nucl.Instrum.Meth.**A388**:64-78,1997*
3. Stephen Godfrey (Ottawa Carleton Inst. Phys.), JoAnne L. Hewett (SLAC), Lawrence E. Price (Argonne), "Discovery Potential For New Phenomena", *Proc. of 1996 DPF / DPB Summer Study on New Directions for High-Energy Physics (Snowmass 96), Snowmass, CO, 1996*
4. I. Ambats, D.S. Ayres, J.W. Dawson, J.H. Hoftiezer, W.A. Mann, E.N. May, N.M. Pearson, L.E. Price, K. Sivaprasad, N. Solomey, J.L. Thron (Argonne), T.H. Joyce (Minnesota U.), "Construction and Operation of a Drift Collection Calorimeter", *IEEE Trans.Nucl.Sci.**32**:711,1985*

OTHER PUBLICATIONS

1. M. Barone, et al., editors, “Astroparticle, particle and space physics, detectors and medical physics applications”, *World Scientific (2006)*
2. Soudan 2 Collaboration (D. Wall et al.), "Search For Nucleon Decay Into Lepton + K0 Final States Using Soudan 2", *Phys.Rev.D61:072004,2000*
3. Soudan 2 Collaboration (W.W.M. Allison et al.), "The Atmospheric Neutrino Flavor Ratio From a 3.9 Fiducial Kiloton Year Exposure of Soudan-2", *Phys.Lett.**B449**:137-144,1999*
4. C.T. Day, S. Loken, J.F. MacFarlane (LBL, Berkeley), E. May, D. Lifka, E. Lusk, L.E. Price (Argonne), A. Baden (Maryland U.), R. Grossman, X. Qin (Illinois U., Chicago), L. Cornell, P. Leibold, D. Liu, U. Nixdorf, B. Scipioni, T. Song (SSCL)," Database Computing In HEP: Progress Report", *Proceedings of 10th International*

Conference on Computing in High-energy Physics Annecy, France, pp. 557-560, 1992

5. Soudan-2 collaboration (W.W.M. Allison et al.), "The Soudan-2 Detector: the Operation And Performance of the Tracking Calorimeter Modules", *Nucl.Instrum.Meth.**A381**:385-397,1996*
6. HRS Collaboration (S. Abachi et al.), "Measurement of The Branching Ratio for $\tau^- \rightarrow e^- \nu_e \nu_\tau$ ", Phys.Lett**.B226**:405-409,1989

SYNERGISTIC ACTIVITIES

Fellow, American Physical Society
International Advisory Committee on Generic Detector R&D for the SSC 1987-1993
Chairman, International Conference on Detector Simulation for the SSC, 1987
1990-2005: International Computing and Networking Coordination. Organization and leadership of several high level coordination committees.
Int'l Advisory Committee, Conferences on Computing in HEP, 1995-2004 (Conference Chairman, 1998)
Chairman, ESnet Steering Committee, 1996-2005 (member since 1989)
Organizing Committee, American Physical Society Study on "New Directions for High Energy Physics," Snowmass, CO., June 26-July 12, 1996
US/China Joint Committee on Cooperation in High Energy Physics, 1993-2005
High Energy Physics Advisory Panel 1998-2001
Organizing Committee, International Conferences on Advanced Technology and Particle Physics 2005-Present

COLLABORATORS & OTHER AFFILIATIONS

a) Collaborators
I am a member of the ATLAS collaboration, with approximately 2000 members.
Recent individuals with whom I have worked closely include: Howard Gordon (BNL), Mike Tuts (Columbia), James Pilcher (Univ. Chicago), Ana Henriques (CERN), Christian Bohm (Univ. Stockholm), Francois Vazeille (Clermont-Ferrand, France), Tarcisio del Prete (Univ Pisa and INFN).

b) Graduate Advisor
Richard Wilson, retired.

c) Postdoctoral Advisor
Leon Lederman, retired

d) Advisees
Graduate Students: Keith Jenkins
Postdoctoral Scientists: Enrique Fernandez

Sergio Rescia
Brookhaven National Laboratory
Instrumentation Division - Bldg 535B, Upton, NY 11973

EDUCATION

2000 **Ph.D.** - Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia.
1984 **M.S.** Electrical Engineering University of Pavia, Italy.

PROFESSIONAL BACKGROUND

2003-present	Scientist, Brookhaven National Laboratory
1993-2003	Electrical Engineer, Brookhaven National Laboratory
1989-1993	Associate Electrical Engineer, Brookhaven National Laboratory
1984-1989	Assistant Electrical Engineer, Brookhaven National Laboratory, Upton, NY
1983-1984	Research Assistant, University of Pavia, Italy

SELECTED PUBLICATIONS PERTINENT TO THIS PROPOSAL

1. "Commercial Buck Converters and Custom Coil Development for the Atlas Inner Detector Upgrade"
Dhawan, S.; Baker, O.; Chen, H.; Khanna, R.; Kierstead, J.; Lanni, F.; Lynn, D.; Musso, C.; Rescia, S.; Smith, H.; Tipton, P.; Weber, M.;
IEEE Transactions on Nuclear Science, Volume: 57 , Issue: 2 , Part: 1 Apr. 2010 , Page(s): 456 – 462

2. "Commercial-Off-the-Shelf DC-DC converters for high energy physics detectors for the sLHC upgrade"
Dhawan, S.; Baker, O.; Chen, H.; Khanna, R.; Kierstead, J.; Lanni, F.; Lynn, D.; Mincer, A.; Musso, C.; Rescia, S.; Smith, H.; Tipton, P.; Weber, M.;
16th IEEE Real Time Conference, 2009. RT '09. Conference Proceedings, Page(s): 129 – 136

3. "A SiGe front-end prototype for the upgraded ATLAS liquid argon calorimeter"
Newcomer, M and Rescia, S.
2009 IEEE Nuclear Science Symposium Conference Record (NSS/MIC), Pages: 1134 – 1137

4. "Effect of sense wire resistance on readout noise of large liquid argon time projection chambers"
Rescia, S.; Radeka, V.;
2009 IEEE Nuclear Science the electronic Symposium Conference Record (NSS/MIC), Pages: 1932 – 1935

5. Performance of readout of the ATLAS liquid argon calorimeters.
H. Abreu et al. 2010.
Published in Journal of Instrumentation Vol. 5 Sept 2010.

OTHER PUBLICATIONS

1. Radiation qualification of the front-end electronics for the readout of the ATLAS liquid argon calorimeters.
   N.J. Buchanan et al. 2008.
   Published in JINST 3:P10005, OCT 2008.

2. Radiation qualification of the front-end electronics for the readout of the ATLAS liquid argon calorimeters.
   N.J. Buchanan et al. 2008.
   Published in JINST 3:P10005, OCT 2008.

3. Time resolution of the ATLAS barrel liquid argon electromagnetic calorimeter.
   M. Aharrouche et al. 2008. 11pp.
   Published in Nucl.Instrum.Meth.A597:178-188, DEC 2008

4. The FP420 R&D Project: Higgs and New Physics with forward protons at the LHC.
   By FP420 R&D Collaboration (M.G. Albrow et al.). FERMILAB-FN-0825-E, Jun 2008.

5. Design and implementation of the Front End Board for the readout of the ATLAS Liquid Argon calorimeters.
   N.J. Buchanan et al. 2008.
   Published in JINST 3:P03004,2008.

SYNERGISTIC ACTIVITIES

Member of Atlas Collaboration

Member of MicroBoone Collaboration

Working on design of Long Baseline Neutrino Experiment (LBNE) LAR Time Projection Chamber

Working on low-noise data acquisition for pre-clinical MRI instrumentation

Working on Beam Control Instrumentation

COLLABORATORS AND CO-EDITORS

I am a member of the Atlas, MicroBoone and LBNE collaborations. Co-authors and collaborators include: Baker, O.;Brooijmans, G.; Chen, H.; Cressler, J. D. ; Damiani, D.; Dhawan, S.; Diez, S.; Gadfort, T.; Grillo, A.; Hackenburg, R. ; Hare, G.; Jones, A. ; Khanna, R.; Kierstead, J. ;Kononenko, W.; Lanni, F.; Lynn, D.; Mandic, W.; Martinez-McKinney, F.; Metcalfe, J. ; Musso, C.; Newcomer, M. ; Parsons, J. A.; Phillips, S.; Radeka, V.; Rice, J. S.; Sadrozinski, H. F.; Seiden, A.; Smith, H.; Spencer, N.; Spieler, H.; Sutton, A. K.; Tazawa, Y.; Tipton, P.; Ullan, M.; Weber, M; Wilder, M.; Wulf, E.

GRADUATE ADVISOR

Van deer Spiegel, Jan

Manfredi, Pier Francesco (Retired)

ROBERT DEAN SCHAMBERGER JR.

(A) CURRICULUM VITAE

DATE OF BIRTH:	June 28, 1948
ADDRESS:	Department of Physics State University of New York Stony Brook NY 11794
e-Mail:	dean at sbhep.physics.sunysb.edu
EDUCATION:	SUNY at Stony Brook, Major: Physics, B.S.(1970) SUNY at Stony Brook, Major: Physics, Ph.D. (1976) SUNY at Stony Brook, Area: High Energy Physics, (1976-1981)

(B) APPOINTMENTS

EMPLOYMENT:	Technical Director of the High Energy Physics Laboratories (1993 –) Principal Research Scientist, SUNY Stony Brook (1988 – 1993) Senior Staff Scientist, SUNY Stony Brook (1985 – 1988) Senior Research Associate, SUNY Stony Brook (1981 – 1985) Research Associate, SUNY Stony Brook (1976 – 1981)
OTHER:	Co-Principal Investigator, National Science Foundation (1980 –)

(C1) PUBLICATIONS RELATED TO THIS PROPOSAL

1. "Beam Tests of the DØ Uranium Liquid Argon End Calorimeters", S. Abachi *etal.*, Nucl. Instrum. and Meth. A**324**, 53, 1992.

2. "The Upgraded DØ Detector", V.M. Abazov *etal.*, Nucl. Instrum. Methods in Phys. Res. A **565**, 463 (2006).

3. "Measurement of the W Boson Mass", V.M. Abazov *et al*, Phys. Rev. Lett. **103**, 141801 (2009).

4. "Observation of Single Top-Quark Production", V.M. Abazov *etal.*, Phys. Rev. Lett. **103**, 092001 (2009).

5. "Search for Dark Photons from Supersymmetric Hidden Valleys" V.M. Abazov *etal.*, Phys. Rev. Lett. **103**, 081802 (2009).

(C2) OTHER PUBLICATIONS

1. "E1 Transitions from the Υ'' State and the Fine Structure of the χ_b States ", M. Narain, D. M. J. Lovelock, U. Heintz, J. Lee-Franzini, R. D. Schamberger, J. Willins, C. Yanagisawa., P. Franzini, P. M. Tuts, S. Kanekal, and Q. W. Wu, Phys. Rev. Lett. <u>66</u>, 3113 (1991).
2. " Measurement of the B^* Cross Section at $\sqrt{(s)} = 10.61$ to 10.70 GeV", Q.W. Wu, P. Franzini, S. Kanekal, P.M. Tuts, U. Heintz, J. Lee- Franzini, M. Narain, R.D. Schamberger, J. Willins, and C. Yanagisawa, Physics Letters <u>B273</u>, 177 (1992).
3. "Top Quark Search with the DØ 1992 – 93 Data Sample", S. Abachi *etal.*, Phys. Rev. <u>D52</u>, 4877 (1995).
4. "CUSB-II: A High Precision Electromagnetic Spectrometer", R. D. Schamberger, U. Heintz, J. Lee-Franzini, D. M. J. Lovelock, M. Narain, J. Willins, C. Yanagisawa, P. M. Tuts, P. Franzini, S. Kanekal and Q. W. Wu, Nucl. Inst. and Meth. <u>A309</u> 450, (1991).
5. "Search for Resonant Diphoton Production with the DØ Detector", V.M. Abazov *etal.*, Phys. Rev. Lett. **102**, 231801 (2009).

(D) SYNERGISTIC ACTIVITIES

Organize the Operating Calorimeters session of the CALOR 2008 conference, 26 - 30 May 2008, Pavia Italy.

(E1) OTHER COLLABORATORS

D0 collaboration (http://www-d0.fnal.gov/ madaras/authorlist.html)
Atlas collaboration (http://graybook.cern.ch/programmes/experiments/lhc/ATLAS.html)

(E2) ADVISOR

(Ph.D. Thesis and Postdoc Advisor): Juliet Lee-Franzini (Laboratori Nationali di Frascati dell'INFN, Frascati, Italy)

(E3) PEOPLE I SUPERVISED

(Recent Postdoc and students): Nirmalya Parua(PD), Adam Yurkewicz(PD), and Rafael Lopes De Sa (GS)

(past PostDoc and Students): 8 PostDocs and 6 Grad Students

Total: 17

Sally Seidel
University of New Mexico

Biographical Sketch

Sally Seidel received her Ph.D. in experimental particle physics from the University of Michigan in 1987 for a search for nucleon decay using the IMB water Cherenkov detector. As a research scientist with the University of Toronto on the ARGUS Experiment from 1987-1991, she participated in the construction of a drift chamber optimized for B physics and published a study of charmed baryon decay. Seidel joined the University of New Mexico faculty in 1991. She is a member of the CDF experiment at Fermilab, for which she co-led the upgrade tracker sensor design team and carried out a study of multi-jet final states, and the ATLAS experiment at the LHC, where she co-led the pixel sensor group. On ATLAS she is presently searching for excited heavy mesons and developing the technology for the upgrade pixel detector. She has served on the DOE High Energy Physics Advisory Panel and the Fermilab Users Executive Committee and has held the position of Secretary-Treasurer of the APS Topical Group on Hadronic Physics. She was recently elected Vice Chair of the Four Corners Section of the APS.

Professional Preparation

Yale University	Physics	B.S. 1980
University of Michigan	Physics	M.S. 1983
University of Michigan	Physics	Ph.D. 1987
University of Toronto	Research Scientist	1987-1991

Appointments

University of New Mexico

Professor	2004-present
Associate Professor	1997-2004
Assistant Professor	1991-1997

Royal Institute of Technology, Stockholm

Visiting Professor	2008-2009

Lund University

Visiting Professor	2006-2007

Publications Most Closely Related to the Project

1) "ATLAS Pixel Radiation Monitoring with the HVPP4 System," I. Gorelov, M. Hoeferkamp, S. Seidel, and K. Toms, arXiv:0911.0128[hep-ex].

2) "Capacitance Simulations and Measurements of 3D Pixel Sensors Under 55 MeV Proton Exposure," J.E. Metcalfe, I. Gorelov, M. Hoeferkamp, and S. Seidel, IEEE Trans. Nucl. Sci. Vol. 55, Issue 5, Part 2 (2008) 2679-2684.

3) "Electrical Characteristics of Silicon Pixel Sensors," I. Gorelov, et al. (S. Seidel, corresponding author), Nucl. Instr. and Meth. A 489 (2002) 202-217.

4) "A Review of Design Considerations for the Sensor Matrix in Semiconductor Pixel Detectors for Tracking in Particle Physics Experiments," S. Seidel, Nucl. Instr. and Meth. A 465 (2001) 267-296.

5) "Capacitance of Silicon Pixels," G. Gorfine, M. Hoeferkamp, G. Santistevan, and S. Seidel, Nucl. Instr. and Meth. A 460 (2001) 334-349.

Other Significant Publications

1) "Comparison of Three-Jet Events in Proton-Antiproton Collisions at $s^{1/2}$ =1.8 TeV to Predictions from a Next-to-leading Order QCD Calculation," D. Acosta et al (S. Seidel, corresponding author), Phys. Rev. D 71, 032002 (2005).

2) "The ATLAS Silicon Pixel Sensors," M. Alam et al. (S. Seidel, corresponding author), Nucl. Instr. and Meth. A 456 (2001) 217-232.

3) "Measurement of Proton-induced Radiation Damage in Double-sided Silicon Microstrip Detectors," A. Brandl, S. Seidel, and S. Worm, Nucl. Instr. and Meth. A 399 (1997) 76-84.

4) "Evidence for W Exchange in Charmed Baryon Decays," H. Albrecht et al., Phys. Lett. B 342 (1995) 397-401.

Synergistic Activities

1) Co-director, Los Alamos Summer School in Physics REU Site, 1999-2009

2) Lecturer, New Mexico Visiting Scientist Program, which provides science lectures to K-12 classrooms throughout New Mexico

3) Member, APS Committee on the International Freedom of Scientists, 2005-2007

4) Mentor, UNM-NASA PURSUE Program, 1998-2002. Ten of the 23 undergraduates and high school students who have conducted research in the Seidel laboratory are members of under-represented groups in physics.

5) Host, QuarkNet Workshop at UNM for High School Physics Teachers, Oct. 2009.

Collaborators and Co-Editors

The ATLAS Collaboration
The CDF Collaboration
The RD42 Collaboration
The RD50 Collaboration
James Colgan, Los Alamos National Laboratory

Graduate Advisor and Postdoctoral Sponsor

Lawrence Sulak, Boston University
James Prentice, retired from the University of Toronto

Thesis Advisor and Recent Postgraduate Scholar Advisor

1) Alexander Brandl, Austrian Research Centers, Health Physics Division
2) Wei-na Ji, Lund University
3) Jessica Metcalfe, University of New Mexico
4) Rui Wang, University of New Mexico
5) Konstantin Toms, University of New Mexico
6) Elena Vataga, University of Southampton

Total number of doctoral students advised: 4
Total number of postdoctoral fellows advised: 8

Abraham Seiden
Santa Cruz Institue for Particle Physics (SCIPP)
UC Santa Cruz Department of Physics

PROFESSIONAL PREPARATION

Columbia University	Applied Physics	B.S.	1967
California Institute of Technology	Physics	M.S.	1970
University of California, Santa Cruz	Physics	Ph.D.	1974

POST DOCTORAL APPOINTMENTS

1975-1976	Postdoctoral Research Scientist, High Energy Physics, University of California, Santa Cruz
1974-1975	Visiting Scientist, CERN

APPOINTMENTS

2008-present	Distinguished Professor of Physics, University of California, Santa Cruz
1981-2010	Director, Santa Cruz Institute for Particle Physics
1986-2008	Professor of Physics, University of California, Santa Cruz
1985-1986	Visiting Scientist, European Laboratory for Particle Physics (CERN)
1981-1985	Associate Professor of Physics, University of California, Santa Cruz
1978-1981	Assistant Professor of Physics, University of California, Santa Cruz
1976-1978	Assistant Professor of Physics in Residence, University of California, Santa Cruz

SELECTED PUBLICATIONS PERTINENT TO THIS PROPOSAL

1. Radiation-hard semiconductor detectors for Super LHC.
   M. Bruzzi *et al*. Nucl. Instrum. Meth. A 541, 189 (2005).

2. Tracking detectors for the sLHC, the LHC upgrade.
   H.F.-W. Sadrozinski and A. Seiden. Nucl. Instrum. Meth. A 541, 434 (2005)

3. The Particle Tracking Microscope PTSM.
   H. F.-W. Sadrozinski *et al*. IEEE Trans. Nucl. Sci., 51(5): 2032-2036, 2004.

4. Ionization Damage on Atlas-SCT Front-End Electronics considering Low-Dose-Rate Effects.
   M. Ullan *et al*., IEEE Trans. Nucl. Sci. 49:1106-1111, 2002.

5. The BaBar silicon vertex tracker, performance and running experience.
   V. Re et al., Nuclear Instruments and Methods A 485, 10(2002).

OTHER PUBLICATIONS

1. Search for CP Violation in the Decays D0 → K-K+ and D0 → pi-pi+.
   B. Aubert et al. (BaBar Collaboration), Phys. Rev. Lett. 100:061803 (2008).

2. Evidence for D0-anti-D0 Mixing.
   B. Aubert *et al*. (BaBar Collaboration). Phys. Rev. Lett. 98:211802 (2007).

3. Search for D0-anti-D0 Mixing and Branching-Ratio Measurement in the Decay D0 → K+pipi0.
   B. Aubert *et al*. (BaBar Collaboration). Phys. Rev. Lett. 97:221803 (2006).

4. Limits on D0-anti-D0 mixing and CP violation from the ratio of lifetimes for decay to K-pi+, K-K+ and pi-pi+.
   B. Aubert *et al*. (BaBar Collaboration). Phys. Rev. Lett. 91:121801 (2003).

5. Tracking at the SSC/LHC.
   H. F.-W. Sadrozinski, A. Seiden, A. Weinstein, Nuclear Instruments and Methods A 279, 223, 1998.

SYNERGISTIC ACTIVITIES

Author of a textbook on particle physics: "Particle Physics, A Comprehensive Introduction", published by Addison Wesley in 2005.

Have had significant service roles for US ATLAS, various laboratories, the US High Energy Physics Program and other areas of physics. Examples, with dates of service are given below.

2010	Member of DUSEL Program Advisory Committee
2009	Member of Particle Astrophysics Scientific Assessment Group
2005-present	Manager, US ATLAS Upgrade Effort
2002-2007	Chair, Particle Physics Project Prioritization Panel
2001-2003	Chair of LIGO Program Advisory Committee
1994-2000	Member of CERN Scientific Policy Committee

COLLABORATORS & OTHER AFFILIATIONS

a) Collaborators
I am a member of the BaBar and ATLAS collaborations with approximately 3000 members. Recent individuals with whom I have worked closely include: Howard Gordon (BNL), Mike Tuts (Columbia), Maurice Garcia-Sciveres (LBNL), Carl Haber (LBNL), M. Gilchriese (LBNL), Phil Allport (Liverpool, U.K.), Nigel Hessey (Nikhef, Holland).

b) Graduate Advisor
Clemens Heusch, retired.

c) Postdoctoral Advisor
Pierre Darriulat, retired

d) Advisees
Graduate Students: Michael Wilson, Christian Flacco, Ken Fowler, Peter Manning (current).
Postdoctoral Scientists: Jovan Mitrevski, Sofia Chouridou.

DONG SU
SLAC National Accelerator Laboratory
MS 95, SLAC, 2575 Sand Hill Road, Menlo Park, California 94025
Phone: 650-926-2284
E-mail: sudong@slac.stanford.edu

I. EDUCATION

Imperial College, University of London	Ph. D., Physics	May, 1987
Imperial College, University of London	B.Sc.,Physics	June, 1983

II. ACADEMIC CAREER

1/2004 -	Associate Professor	SLAC National Accelerator Laboratory, CA
1/1997 -12/2003	Assistant Professor	SLAC National Accelerator Laboratory, CA
6/1993 -12/1998	Research Associate	SLAC National Accelerator Laboratory, CA
6/1988- 5/1993	Research Associate	Rutherford Appleton Laboratory, UK

III. RESEARCH EXPERIENCE

2006-present	Head of SLAC ATLAS department, with direct supervision of the various tracking and trigger/DAQ upgrade projects in particular.
1999-2006	BaBar trigger system manager.
2000-2005	BaBar L1 Drift-Chamber Trigger upgrade project leader for design, construction and initial commissioning and operations.
1997-2005	BaBar L1 Global Trigger manager for design, construction and operations
1994-2006	SLD Heavy Flavor physics working group leader.
1995-2002	Liason between SLD and LEP Electroweak working group and a member of the LEP+SLD+CDF heavy flavor physics steering group.
1994-1998	Key contribution in design, commissioning and physics application of the upgrade SLD CCD pixel vertex detector.
1988-1994	Key contribution to the construction, commissioning and physics application of the original SLD CCD pixel vertex detector. Commissioner 1992-1995.
2004-2005	GLAST trigger commissioning coordinator.
2005-2007	Co-coordinator of vertex detector working group of SiD concept for ILC.

IV. Publications

Dong Su has over 500 publications in peer reviewed journals with the ATLAS, BaBar, SLD and TASSO Collaborations and some additional instrumentation and physics review papers.

Selected publications related to building detectors

- "Rapid 3D Track Reconstruction with the BABAR Trigger Upgrade," S. Bailey *et al*., Nucl. Instrum. and Meth. in Phys. Res. A **518**, 544 (2004).
- "The BaBar Detector," B. Aubert *et al*., Nucl. Instrum. and Meth. in Phys. Res. A **479**, 1 (2002). (Editor of trigger chapter)

- "Internal Alignment of the SLD Vertex Detector Using a Matrix Singular Value Decomposition Technique," D. J. Jackson, D. Su and F. J. Wickens, Nucl. Instrum. and Meth. in Phys. Res. A **491**, 351 (2002).
- "Design and Performance of the SLD Vertex Detector, a 307 Mpixel Tracking System," K. Abe *et al.*, Nucl. Instrum. and Meth. in Phys. Res. A **400**, 463 (1997).
- "Design and Performance of the SLD Vertex Detector, a 120 Mpixel Tracking System," G. Agnew *et al.*, SLAC-PUB-5906, Proceedings of the XXVI International Conference on High Energy Physics, Aug 1992, Dallas Texas, edited by J.Sanford.

Selected other significant publications

- "A Study of jets from b Quarks Produced in e^+e^- Annihilations at root(s)=35-46 GeV", W. Braunschweig *et al.* (TASSO Collaboration), Zeit. Phys. **C42**, 17 (1989).
- "Heavy Quark Couplings to the Z^0," D. Su, SLAC-PUB-1997-053, Contribution for an invited plenary talk in the Proceedings of the XVIII International Symposium on Lepton-Photon Interactions, July/97, p439 (published by World Scientific)
- "Highlights of the SLD Physics Program at the SLAC Linear Collider", P. C. Rowson, D. Su and S. Willocq, Ann. Rev. Nucl. Part. Sci. **51**, 345 (2001).
- "Measurement of the branching ratio of the Z^0 into heavy quarks," K. Abe *et. al.* (SLD Collaboration), Phys. Rev. **D71,** 112004 (2005).

V. SYNERGISTIC ACTIVITIES

- Member of Physics Advisory Committee for Fermilab, 2003-2006.
- Member of the International Advisory Committee for the Physics in Collision Conference since 1998 and chaired the 2002 edition at Stanford.
- Member of International Advisory Committee for the International workshop on vertex detectors, since Jan/2007.

VI. CURRENT COLLABORATORS / CO-EDITORS

- ATLAS Collaboration (http://atlas.web.cern.ch/Atlas/Welcome.html)
- BaBar Collaboration (http://www.slac.stanford.edu/BFROOT/)

VII. ADVISEES

Former postdocs (still in HEP):

- Sarah Demers (Yale), Valerie Halyo (Princeton), Selina Li (SLAC), Kai Yi (U Iowa)

Former graduate students:

- Nicolas P. Berger (LAPP Annecy, France)

VIII. ADVISORS

- (Postdoctoral) R,.Schindler, SLAC
- (Postdoctoral) C. Damerell, Rutherford Appleton Laboratory
- (Ph.D. Thesis) D.Binnie, Imperial College, University of London

Helio Takai
Physics Department
Brookhaven National Laboratory

PROFESSIONAL PREPARATION

Postdoctoral	University of Pittsburgh
Ph.D. Physics	University of Rio de Janeiro, 1986
M.Sc. Physics	University of São Paulo, Brazil, 1982
B.Sc. Physics	University of São Paulo, Brazil, 1980

APPOINTMENTS

Adjunct Professor, Physics Department, Stony Brook University (2005 - to present)
Physicist, Physics Department, BNL (1995 - to present)
Associate Physicist, Physics Department, BNL (1992-1995)
Assistant Physicist, Physics Department, BNL (1990-1992)
Research Associate, Physics Department, BNL (1989-1990)
Research Associate, Dept. Physics & Astronomy, Pittsburgh (1986-1989)
Lecturer, University of Rio de Janeiro (1983-1986)

SELECTED PUBLICATIONS PERTINENT TO THIS PROPOSAL

1. The ATLAS Collaboration, Observation of a centrality-dependent dijet asymmetry in lead-lead collisions at sqrt(s_NN) = 2.76 TeV with the ATLAS detector at the LHC. Phys. Rev. Lett. 105, 252303 (25 Nov 2010)
2. The ATLAS Collaboration, Charged-particle multiplicities in pp interactions at sqrt(s) = 900 GeV measured with the ATLAS detector at the LHC. Phys.Lett.B688:21-42,2010
3. Bugallo, M.F., Takai, H., Marx, M., Bynum, D., Hover, J. MARIACHI: Hands-on engineering and science: Discovering cosmic rays using radar techniques and mobile technology, Acoustics, Speech and Signal Processing, 2009, pp 2321-2324
4. S. Aronson et. al., A nuclear physics program at the ATLAS experiment at the CERN Large Hadron Collider, arXiv:nucl-ex/0212016 (2002)
5. O. Benary et al., Precision Timing with Liquid Ionization Calorimeters, Nucl. Inst. and Methods, A332, 78-84(1993)

OTHER PUBLICATIONS

1. Bugallo, M.F., Takai, H., Marx, M., Bynum, D., Hover, J. MARIACHI: A multidisciplinary effort to bring science and engineering to the classroom, Acoustics, Speech and Signal Processing, 2008, pp 2661-2664
2. T. Terzella, J. Sundermier, J. Sinacore, C. Owen, and H. Takai, *Measurement of g using a Flashing LED*. Phys. Teach. 46, 395 (2008)
3. A. Berntson,V. Stojanoff and H. Takai, Application of a neural network in high-throughput protein crystallography, Journal of Sync. Radiation 10, 445-449 (2003)

4. J. Barrette et al. (E814 collaboration), Two proton correlations from 14.6A-Gev/c Si+Pb and 11.5A-GeV/c A Central Collisions, Phys. Rev. C60(1999)

5. D.F. Winchell, M.S. Kaplan, J.X. Saladin, H. Takai, J.J. Kolata and J. Dudek, High Spin states in 75Kr: approaching superdeformation in the A=80 region, Physical Review C40, 2672(1989)

SYNERGISTIC ACTIVITIES

1. Member of Particle and Nuclear Astrophysics NSF Panel, 2009 and 2011
2. Fellow of the Royal Astronomical Society (2004)
3. Convener of the ATLAS experiment Heavy Ion Physics Group and member of the ATLAS Physics coordination(2002-2006)
4. Mentor for QuarkNet, (2000 - to present)
5. XXXVII International Symposium on Multi Particle Dynamics, Local Organizing Committee, Berkeley, August 4-10,2007
6. Workshop on p-Nucleus Collisions at the LHC, co-organizer, CERN, May 25-28, 2005
7. Mentor for DOE Educational Programs - LSTPD, SULI and PST , Outstanding DOE Mentor, 2003 and 2006
8. Mentor for Stony Brook URECA and Simmons program.

COLLABORATORS & OTHER AFFILIATIONS

Collaborations

2000	Test Methodology for low cost Radiation Resistant Power Supplies
1994-present	The ATLAS Experiment, liquid argon calorimenter, heavy ion physics coordination (2002-2006), liquid argon electronics upgrade (2010 - today)
1995	AGS Experiment E889 Proposal - Long Baseline Neutrino Experiment
1992 - 1993	GEM experiment - Superconducting Super Collider, Dallas, Texas
1990	The OASIS experiment at RHIC, letter of intent
1989 - 1993	Experiment E814 - Heavy Ion Physics, Brookhaven National Laboratory

Thesis Advised

1. Nelson Canzian da Silva, Universidade de São Paulo, PhD in Nuclear Physics
2. Marco Antonio Lisboa Leite, Universidade de São Paulo, PhD in Nuclear Physics
3. Nishant Mehta, Cornell University, M.S.
4. Cristina Schoch Viana, Universidade Federal do Rio de Janeiro, M.S.
5. Tara Falcone, Stony Brook University, MAT

Curriculum Vitae
Paul L. Tipton

Department of Physics
Yale University
New Haven, CT 06511
Telephone: (203) 432-3375
Fax: (203) 432-6175
Email: paul.tipton@yale.edu

Education

1979 B.S., Physics , SUNY Binghamton
Phi Beta Kappa, George E. Moore Award for Outstanding Undergraduate Research
1987 Ph.D., Physics, University of Rochester
Thesis Advisor, E.H. Thorndike, Dexter Prize for Outstanding Graduate Research, 1985

Appointments

1987-1990 Post-doctoral Fellow, Lawrence Berkeley Laboratory
1990-1991 Wilson Fellow, Fermi National Accelerator Laboratory
1991-1996 Assistant Professor, University of Rochester
1996-2000 Associate Professor, University of Rochester
2000-2006 Professor, University of Rochester
2006- Professor, Yale University

Fellowships and Awards:

- National Science Foundation Young Investigator Award (1992—97)
- Outstanding Junior Investigator Award, U.S. Department of Energy (1991—1996)
- Univ. of Rochester Dept. of Physics and Astronomy Annual Award for Excellence in Teaching (1995)
- Teacher of the Year, Honorable Mention , University of Rochester Student's Association, (1994)
- Fellow, American Physical Society (2001—Present)

Synergistic Activities and Scientific Collaborations:

- Member of Physics Advisory Committee (PAC) for Fermilab's Directorate (2000—2005)
- Member, Editorial and Planning Committee for the journal *Annual Review of Nuclear and Particle Science (ARNPS)* (2003—2008)
- Spokesperson for the Principle Investigators, University of Rochester HEP DOE Grant (1999—2006)
- Spokesperson for the Principle Investigators, Yale University HEP DOE Grant
- (2007-Present)
- Member of the CDF Collaboration (1987—2011)
- Member of the CMS Collaboration (2001—2006)
- Member of the ATLAS Collaboration (2006—Present)

Graduate (12) and Postdoctoral (10) Advisees:

- Mr. Richard Wall (current graduate student)
- Mr. Benjamin Auerbach (current graduate student)
- Ms. Sarah Lockwitz (current graduate student)
- Mr. Benjamin Kaplan (current graduate student)
- Ms. Jennifer Gimmel (now teaching at Loyola Academy, Wilmette, Il)
- Dr. Ricardo Eusebi (now Assistant Prof. at Texas A&M University)
- Dr. Andrew Ivanov (now Assistant Prof. at Kansas State University)
- Dr. Mircea Coca (now attending medical school)
- Dr. Josh Cassada (now a U.S. Navy test pilot, building a resume for the Astronaut corps)
- Dr. Kirsten Tollefson (now an Assoc. Prof at Michigan State University)
- Dr. Phillip Koehn (now at Institute for Defense Analysis, Washington, D.C.)
- Dr. Gordon Watts (now Assoc. Prof. of Physics at University of Washington).

- Dr. Jahred Adelman (current postdoctoral fellow)
- Dr. Andrei Loginov (current postdoctoral fellow)
- Dr. Ulrich Husemann (now a Helmholtz Young Investigator at DESY)
- Dr. Andy Hocker (now Tenure-Track Scientist, Fermilab)
- Dr. Eva Halkiadakis (now Asst. Prof. at Rutgers University)
- Dr. Steven Blusk (now Assoc. Prof. at Syracuse University)
- Dr. Mark Kruse (now Assoc. Prof. at Duke University)
- Dr. Yi Cen (now at Hewlett Packard)
- Dr. Richard Hughes (now Professor at The Ohio State University)
- Dr. Brian Winer (now Professor at The Ohio State University).

Selected Publications (of more than 450 total)

Measurement of the top quark pair production cross-section with ATLAS in pp collisions at $\sqrt{s}$ = 7 TeV, The ATLAS Collaboration, submitted to Eur. Phys. Journal C (2010).

Search for the Flavor Changing Neutral Current Decay t->Zq in pp collisions at $\sqrt{s}$ = 1.96 TeV, T. Aaltonen et al, The CDF Collaboration, Phys. Rev. Lett., **101**, 192002 (2008).

Search for Charged Higgs Bosons from Top Quark Decays in p-pbar Collisions at ps = 1.96 TeV, D. Acosta et al., The CDF Collaboration, Phys. Rev. Lett. **96**, 042003 (2006).

Search for Anomalous Kinematics in Top-Antitop Dilepton Events at CDF II, D. Acosta et al., The CDF Collaboration, Phys. Rev. Lett. **95**, 022001 (2005).

Evidence for Top Quark Production in Proton-Antiproton Collisions at $\sqrt{s}$ = 1.96 TeV, F. Abe et al. (CDF Collaboration), Phys. Rev. Lett. 73, 225 (1994).

Synergistic Activities

DC-DC converter development with Yale University.

Collaborators and Co-editors

ATLAS Experiment, STAR Experiment, PP2PP Experiment

Thesis Advisor

Prof. Peter Schlein, University of California, Los Angeles

Hugh H. Williams
Department of Physics and Astronomy
University of Pennsylvania

Professional Preparation:

1966	B.S. Physics	Haverford College
1972	Ph.D. Physics	Stanford University

1972-1973 Postdoctoral Fellow, Brookhaven National Laboratory

Professional Appointments:

2009- Mary Amanda Wood Professor of Physics and Astronomy, University of Pennsylvania
1982-2009 Professor, Department of Physics and Astronomy, University of Pennsylvania
1981 Scientific Associate, CERN
1978-1982 Associate Professor, Department of Physics and Astronomy, University of Pennsylvania
1978 Visiting Scientist, KEK National Laboratory
1974-1978 Assistant Professor, Department of Physics and Astronomy, University of Pennsylvania
1973-1974 Associate Physicist, Brookhaven National Laboratory

Selected Publications: (only instrumentation publications here)

G. Aad et al. (ATLAS Collaboration), Expected Performance of the ATLAS Experiment Detector, Trigger and Physics, (Jan. 2009).
E. Abat et al. (ATLAS Collaboration), The ATLAS TRT End-cap Detectors, *JINST* 3 P10003 (2008).
E. Abat et al. (ATLAS Collaboration), Combined Performance Tests Before Installation of the ATLAS Semiconductor and Transition Radiation Tracking Detectors, *JINST* 3 P08003 (2008).
E. Abat et al. (ATLAS Collaboration), The ATLAS TRT Electronics, *JINST* 3 P06007 (2008).
E. Abat et al. (ATLAS Collaboration), The ATLAS TRT Barrel Detector, *JINST* 3 P02014 (2008).
G. Aad et al. (ATLAS Collaboration), The ATLAS Experiment at the CERN Large Hadron Collider, *JINST* 3S08003 (2008).
T. Akesson et al. (ATLAS TRT Collaboration), Status of Design and Construction of the Transition Radiation Tracker (TRT) for the ATLAS Experiment at the LHC, *Nucl.Instrum.Meth.* A522 131-145 (2004).
T. Akesson et al. (ATLAS TRT Collaboration), Operation of the ATLAS Transition Radiation Tracker Under Very High Irradiation at the CERN LHC, *Nucl.Instrum.Meth.* A522 25-32 (2004).
F. Anghinolfi et al., DTMROC-S: Deep Submicron Version of the Readout Chip for the TRT Detector in ATLAS, *Colmar 2002, Electronics for LHC Experiments*, 95-99.
N. Dressnandt, N. Lam, F.M. Newcomer, R. Van Berg and H.H. Williams, Implementation of the ASDBLR Straw Tube Readout ASIC in DMILL Technology, *IEEE Trans.Nucl.Sc.* TNS-00152 (2000).

Honors and Awards:

1997 Fellow, American Physical Society
1975-1977 Alfred P. Sloan Fellow
1966-1968 National Science Foundation Fellow
1966 Woodrow Wilson Fellow
1966 Phi Beta Kappa

Synergistic Activities:

2010 - Member, USATLAS Executive Commitee
1995 - Penn Representative in ATLAS Collaboration Board
1995 - Penn Representative in TRT Institutional Board
1993 - Principle Investigator, University of Pennsylvania High Energy Physics Grant (DOE)
2000-2002 Co-coordinator for Front End Electronics for the ATLAS Experiment

Collaborative Efforts

I am a member of the ATLAS and CDF Collaborations. I play a small oversight role in the Penn effort on LSST.

Graduate Advisor

David Leith, SLAC

Postdoctoral Advisor

Robert Adair, Yale, Emeritus Professor
Larry Leipuner, BNL, deceased.

Recent Ph.D. Students:
Current: Michael Hance
Current: Ryan Reece
Current: Jon Stahlman

Recent Postdocs:

2007-Peter Wagner, Ph.D., Texas A&M University
2005-2010 Franck Martin, Ph.D., University of Annecy, Annecy, France, High School instructor in Geneva, Switzerland.
2004-2007 Daniel Whiteson, Ph.D., Berkeley; Assistant Professor, University of Califoriana, Irvine

Jingbo Ye

EDUCATION:

1986 B.Sc., University of Science and Technology of China (USTC).

1992 Ph.D., USTC in conjunction with Swiss Federal Institute of Technology (ETH), Zurich, Switzerland, and the Institute of High Energy Physics (IHEP) Beijing.

EMPLOYMENT:

Since 2009	Tenured Associate Professor in Physics and EE, SMU, Dallas, Texas.
2004-2009	Assistant Professor in Physics and Electrical Engineering, SMU, Dallas, Texas.
1998-2004	Senior Research Associate in Physics, SMU, Dallas, Texas.
1995-1998	Postdoctoral Research Associate in Physics, SMU, Dallas, Texas.
1993-1995	Scientific Associate, CERN, Geneva, Switzerland.
1992-1993	Lecturer, USTC, China.

PROFESSIONAL EXPERIENCE:

I am an experimental particle physicist. From 1989 to 1995 I worked in L3 at LEP on detector simulation, physics data analysis, software development and maintenance. From 1995 to 1998 I worked in CLEO at CESR on detector development for the CLEO III upgrade. Since 1998, I have been a member of ATLAS at LHC. I coordinated the design and construction of the optical link system for the Liquid Argon Calorimeter (LAr) front-end readout. I now lead R&D programs at SMU for upgrades in ATLAS for the sLHC and for LArTPC front-end readout in LBNE.

Hardware projects and Research Infrastructure establishments at SMU:

- I am the Principal Investigator (PI) for the R&D programs at SMU. In this program we successfully developed a 5 Gb/s serializer and a 5 GHz phase-locked-loop for high speed serial data transmission in particle physics experiments. These ASIC developments may find applications in ATLAS, LBNE, and SuperB.
- I am PI at SMU and in the steering group of the Versatile Link collaboration to develop radiation tolerant optical transceivers that conform to industrial standards.
- From 2000 to 2007, I coordinated an international team which designed, constructed, installed and commissioned the radiation tolerant optical links for the ATLAS LAr readout system. I am responsible for this link's maintenance and operation at SMU.
- In 1998 I established the Optoelectronics laboratory in the Department of Physics at SMU. The ATLAS LAr optical link project and other projects were carried out in this lab. Based on the research activities, I won awards of the Major Research Instrumentation Program (MRI) from the National Science Foundation (NSF) and from the Department of Education. These awards, together with funds from the ATLAS projects, the Lightner-Sams Foundation and from the Photodigm Inc., brought up the lab as a state-of-the-art facility for optoelectronics systems. In 2006, I added to this lab the capability to design and develop ASIC chips. I maintain full responsibility for this lab since 2004. Projects in this lab now support three engineers, one technician and a few graduate students from both the Physics and the Electrical Engineering Departments.

Physics Data Analyses and Other Research Activities at SMU:

- Since 2005 I advise one postdoc in the following studies in ATLAS: searches for the Higgs particles in its $Z\gamma$ decay channel, in its Z or W associate production and in its WW decay channel.
- I co-supervised one Ph.D. student in the search for the Dirac magnetic monopole with the ATLAS detector. I supervise another Ph.D. student in DiBoson physics studies ($Z\gamma$ and ZZ channels) with the ATLAS (MC) data. I also supervised Master students in the following studies:

“A Time to Digital Converter Implemented in FPGA”; *“The Production Cross Section Calculation of the Dirac Magnetic Monopole Production through the Two Photon Process”*; *“The Experimental Studies and GEANT4 Based Monte Carlo Modeling on Radiation Effects of Silicon-on-Sapphire Semiconductor Devices”*.
- Since 2008, I am the PI for the Advanced Detector Research (ADR) program supported by the Department of Energy on the “Evaluation of the 0.25 μm Silicon-on-Sapphire technology for ASIC developments for future particle physics detector front-end readout systems”.

SELECTED PUBLICATIONS:
- J. Ye on behalf of the ATLAS Liquid Argon Calorimeter Group, “A Serializer ASIC at 5 Gbps for Detector Front-end Electronics Readout”, presented at the XIV International Conference on Calorimetry in High Energy Physics, May 10-14, 2010, Beijing, China.
- With T.Liu, D. Gong, A. Xiang, C. Liu and M. King, *et al*., presented at the Topical Workshop on Electronics for Particle Physics, Sep. 20-24, 2010, Aachen, Germany, and submitted to JINST for publications: “A 4.9-GHz Low Power, Low Jitter, LC Phase Locked Loop”, “A 16:1 Serializer ASIC for Data Transmission at 5 Gbps”, “Link Model Simulation and Power Penalty Specification of Versatile Link Systems”, “Design and Verification of a Bit Error Rate Tester in Altera FPGA for Optical Link Developments”, “R&D Towards Cryogenic Optical Links”, “Response of a Commercial 0.25 μm Thin-Film Silicon-on-Sapphire CMOS Technology to Total Ionizing Dose”.
- With B. Arvidsson *et al*., “The radiation tolerance of specific optical fibres exposed to 650 kGy(Si) of ionizing adiation”, JINST 4 P07010 (2009).
- With A.Firan *et al.*, “Search for Magnetic Monopoles using the ATLAS Detector” ATL-COM-PHYS-2008-208
- With N.J.Buchanan *et al.*, “Design and Implementation of the Front End Board for the readout of the ATLAS liquid argon calorimeters”, JINST 3, P03004 (2008) and with A. Bazan *et al*., “Atlas Liquid Argon Calorimeter Back End Electronics”, JINST 2, P06002 (2007)
- D.Goldin and J.Ye, “Survey of Higgs Production in Association with W and Z bosons”, ATL-COM-PHYS-2007-064
- J.Ye *et al.*, “Radiation Resistance of Single Frequency 1310-nm AlGaInAs-InP Grating-Outcoupled Surface-Emitting Lasers”, Photonics Technology Letters,Vol.18,No 1, Jan. 2006, pp148-150.
- T.Coan, T.Liu and J.Ye, “A compact apparatus for muon lifetime measurement and time dilation demonstration in the undergraduate laboratory”, Am. J. Phys. 74 (2), Feb. 2006, p.161 – 164.
- With M.-L. Andrieux *et al*., “Single-event upset studies of a high-speed digital optical data link”, Nucl. Instrum. Meth. A 456 (2001) 342-351.
- With R.J.Mountain *et al.*, “The CLEO III ring imaging Cherenkov detector”, Nucl. Instrum.Meth. A 433 (1999) 77
- With M. Acciarri *et al.*,“Tests of QED at LEP Energies using $e^+e^- \rightarrow \gamma\gamma(\gamma)$ and $e^+e^- \rightarrow l^+l^-\gamma\gamma$”, Phys.Lett. B 353 (1995) 136.
- J. Ye, “Meas. of Photon Polarization from 3γ Annihilation of Orthopositronium”, Phys.Lett. A 133 (1988)309.

Synergistic activities: I am a member of ATLAS and LBNE. I am the deputy L2 manager for US-ATLAS LAr upgrade program for sLHC. I am the ATLAS coordinator in the Joint ATLAS-CMS Optoelectronics Working Group to address common issues in development of radiation tolerant optical links.
Collaborators: close collaborations with BNL, Columbia University, CERN and Oxford.
Graduate advisors: X.W.Tang (USTC), J.Ulbricht (ETH) and H.S.Chen (IHEP)
Graduate students advised at SMU: Y.He, T.Dougall, J.Norton, A.Firan, Z.Liang and Y.Li.
Postdocs supervised at SMU: D.Goldin and A.Firan

Brookhaven National Laboratory
Project Title: Proposal for Generic Detector R&D for Hadron Colliders
SC Program Announcement Title: Collider Detector Research and Development Program (LAB 11-438)

Description of Facilities and Resources

BNL has fully equipped laboratories and high bay areas in which to carry out the proposed R&D efforts. In addition BNL has the Instrumentation Division which not only has excellent facilities for designing Application Specific Integrated Circuits, prototype printed circuit boards, and a clean room for silicon detector work, but also has a world class scientific and engineering staff which can contribute to this R&D.

Other Support of Investigator(s)

BNL received in FY11 $1,122,000 via KA150302 for Generic Detector R&D. None of those funds are used for the R&D described in this proposal. Those funds are used mainly to support physicists engaged in work on silicon detectors, long drift liquid argon Time Projection Chambers for a Long Baseline Neutrino Experiment and water based scintillator for neutrino experiments. BNL also receives funding via KA1102054 – the U.S. ATLAS Operations Program, which funds R&D for upgrades which are foreseen for installation in 2017-2018. This proposal addresses longer term generic collider R&D. An ATLAS NSF Cooperative Agreement was submitted in January 2011 for a January 2012 start.